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6,250,000 in 1949—*another new record*

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UNITED STATES STEEL

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NEWTON

tech engineering news

May 1950
Vol. XXXI No. 8

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Cover Design by Fred R. Bentel, G. and Bernard P. Spring, G.

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Published monthly during the school year at Walker Memorial, Cambridge 39, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology. Entered as second class matter, at the Post Office, June 1, 1920, at Boston, Massachusetts under the Act of March 3, 1879. Copyright 1950 by The Tech Engineering News. Subscription per year $1.50. Foreign $2.25. One copy 25 cents.

time

On Precision Clocks and Frequency Standards

By Costa Chitouras, '53

The *accurate* determination of time is of growing concern in this age of precise measurements. The word "accurate" is emphasized because timepieces in the form of clocks and watches which are commonplace today, are useless when it comes to measurements in many technical and scientific fields.

These measurements may take the form of either time, by a precision clock, or frequency, by a frequency standard. The relationship between frequency and time is not as foreign as it may appear at first, for frequency is the *time* rate of recurrence of a cyclical phenomenon. This close relationship is even shown in the similarity of a precision clock and a frequency standard, a precision clock being essentially a frequency standard to which a clock has been added to count the number of cycles executed.

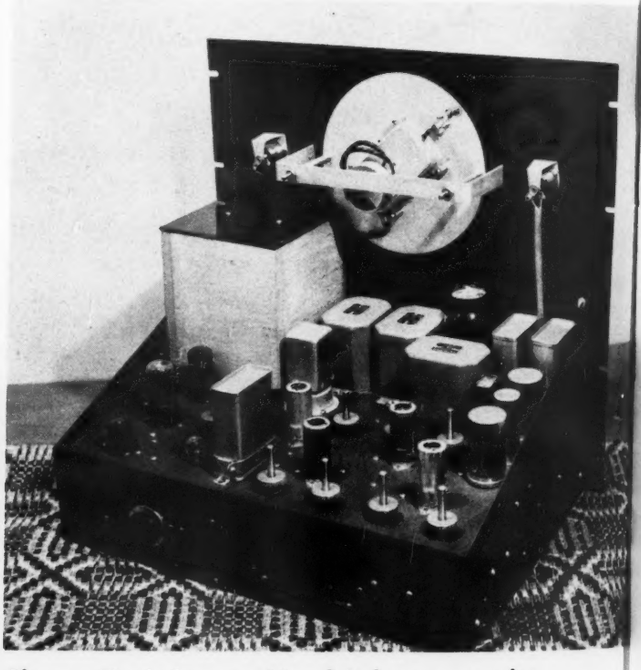
The word "accurate" has been used. As in many cases similar to this, it is impossible to draw a dividing line between an accurate or precision clock and an inaccurate one, but the table opposite shows the approximate requirements of various users of frequency and time services and consequently the requirements which their clocks or frequency standards must meet.

(1×10^{-7} means the frequency must remain within one part in ten million of the desired frequency; in terms of time, the clock will vary a maximum of one second in ten million — approximately four months.)

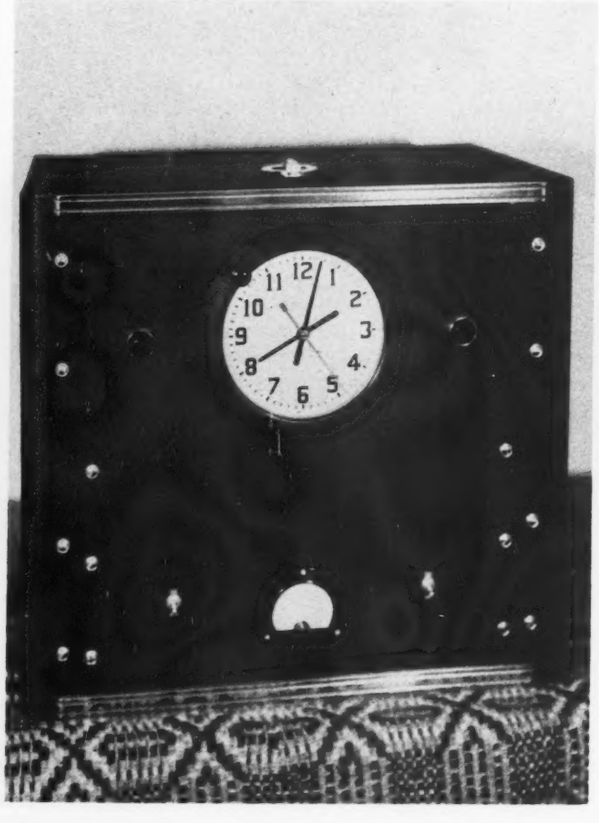
Service	*Accuracy (frequency)*	*Sec./day (time)*
Commercial power distribution	1×10^{-3}	
Commercial communication	1×10^{-5}	$\pm$ 1.0
Radio broadcasting	1×10^{-6}	$\pm$ 0.1
Monitoring stations		
Surveyors	1×10^{-7}	$\pm$ 0.01
Physical research		
Astronomers	1×10^{-8}	$\pm$ 0.001

The present method of controlling clocks to such extraordinary accuracies is through the use of quartz crystals, for even the best mechanical clocks cannot match the performance of the crystal controlled clock. Figure 1 is a simplified block diagram of the essentials of a crystal controlled clock.

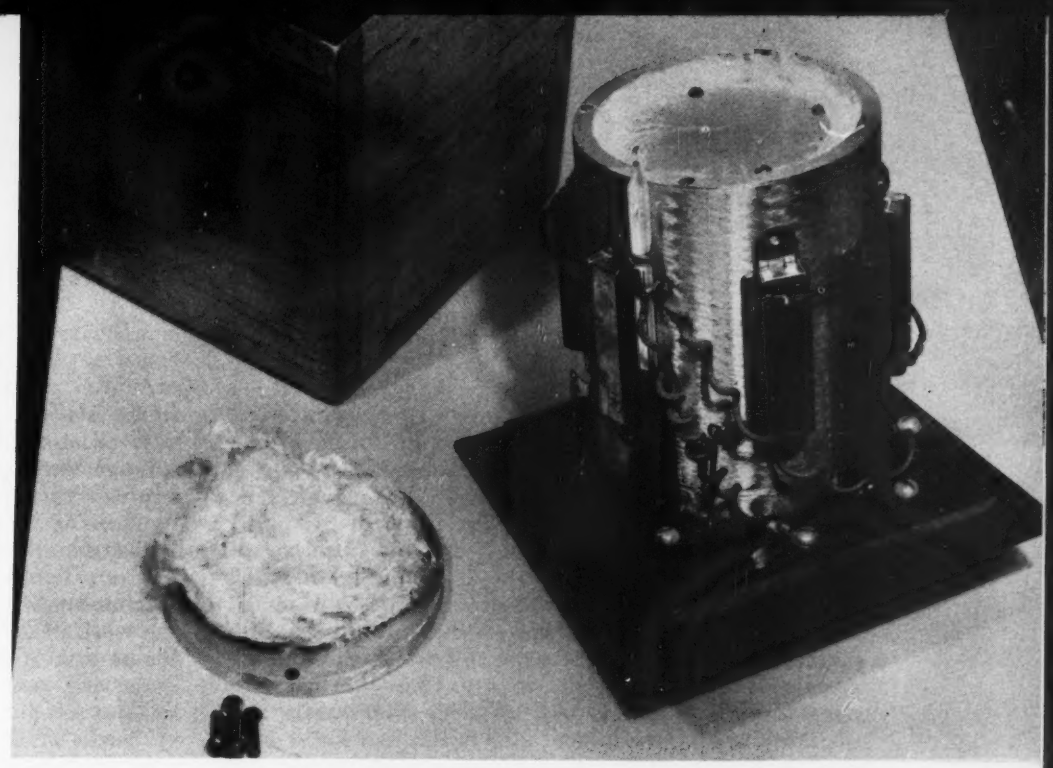
The first and indeed the most critical part of a crystal controlled clock is the crystal oscillator. A crystal oscillator is an electronic circuit which produces a series of electrical oscillations whose period is depend-



Above. The balsa wood insulated oven occupies a large portion of the chassis.



Left. **The complete homemade precision clock. The light on the left is a pilot light; that on the right indicates the on-off cycle of the thermostat.**



The crystal is located within the inner cylinder of the oven.

ent upon the resonant frequency of a crystal used in the oscillator. Since the crystal is the frequency controlling element, any changes in its resonant frequency will cause corresponding changes in the output frequency of the oscillator. Thus, if it were possible to produce a crystal whose frequency never varied, it would then be possible to have a perfect clock or frequency standard. In practice, however, it is found that, among other things, temperature variations and crystal aging are probably the two largest factors which affect the crystal frequency. To minimize these effects, crystals which are used in frequency standards and clocks are enclosed in a temperature controlled "oven" and are cut in a special manner out of pure quartz for minimum ageing variations.

As we have seen, a crystal oscillator is a single frequency device, generally operating at 100 kilocycles. In order that it may be used as the control source for a clock, it is necessary to divide the 100 kilocycles down to a value so that an easily constructed synchronous motor clock may count the cycles executed by the oscillator. Also, in order for the oscillator to act as a frequency standard, the 100 kilocycles must be multiplied to obtain output near the frequency to be measured.

Both of these operations of dividing and multiplying a frequency are performed by a circuit called a multivibrator, which therefore becomes the second essential component of either a precision clock or frequency standard. A multivibrator is itself an oscillator whose frequency is not controlled by a crystal but by a set of resistors and condensers. By choosing suitable values of resistors and condensers, a circuit of this type may be made to oscillate over a very wide range of frequencies. Its usefulness in a precision clock or frequency standard stems from the fact that such an oscillator can be controlled by introducing another voltage whose frequency lies near or is an integral multiple of the natural frequency of the multivibrator. An example will make the preceding statement clearer.

Suppose it were necessary to divide a 100 kilocycle signal down to 10 kilocycles. A multivibrator would be built whose natural frequency was near but not necessarily exactly 10 kilocycles. By introducing the 100 kilocycle signal into the 10 kilocycle multivibrator, the multivibrator would automatically lock into step with the controlling voltage and its frequency would bear an integral relationship to the frequency of the controlling voltage, in this case *exactly* 10 times lower. As stated above a multivibrator can also multiply a frequency. The only difference between such a multivibrator and the one described above is that, one that multiplies must have a natural frequency which is an integral multiple of the controlling voltage.

By having a string of multivibrators, each one controlling a successive one, it is possible to divide the original frequency (usually 100 kilocycles) down to a low value, say 50 cycles, so that it may drive a 50 cycle clock. This final 50 cycles, mind you, has the same accuracy, percentage-wise, as the crystal oscillator.

The astronomical clocks now used by the U. S. Naval Observatory and the National Bureau of Standards work on the same principle. A precision clock built by the author, also working on this principle, is shown in block form in Figure 2. No schematic diagram of this clock is given because, as can be seen from the photographs, the clock is quite complicated, and a complete discussion of the various circuits in it and the adjustments required on it is beyond the scope of this paper. A few facts on its construction and performance will, however, be given.

The entire clock is built on a 17 x 13 x 4 inch, heavy duty, steel chassis with a panel measuring 19 x 17½ x ⅛ inches. Only high quality components were used and must be used if an accuracy as high as this clock possesses is desired. Solid number 12 copper bus bar wire was used whenever possible, especially in the oscillator section. The crystal oscillator is the same as that used in the General Radio Primary Frequency Standard — a bridge type oscillator, the type now used in every high precision clock or frequency standard.

The most critical part of the clock, as far as the building of it was concerned, was the construction of the temperature controlled oven. The crystal is enclosed in an aluminum cylinder, the walls of which are over a quarter of an inch thick. Outside of this cylinder there is a layer of asbestos about a half inch thick which is then surrounded by another aluminum cylinder of similar construction as the first, but of larger dimensions. On the outside of this cylinder are mounted six heaters and the mercury thermostat. This whole unit is then enclosed in a balsa wood container.

The purpose of putting asbestos between the crystal and heaters is to "iron out" the variations of heat input

(*Continued on page 20*)

m. i. t.'s expansion program

New Research Frontiers Require More Space for Exploration

By *T. E. N.* Staff

Two groups within the administrative organization at M. I. T. were responsible for the inception of the now flowering Development Program at Tech. The Academic Council, comprising the academic deans, the Dean of the Graduate School, the Dean of Students, and the Chairman of the Faculty; and the Administrative Council, which includes the Academic Council, the Treasurer, the Bursar, the Registrar and the Dean of Admissions, usually meet every other week to discuss needs of the Institute and ways and means of handling them. With the end of the war there opened new opportunities in finance and all fields of research, and the Administrative Council met to discuss methods of exploiting these openings.

Usually matters taken up in the two councils arise as a result of suggestions and requests from the individual departments. Matters both academic and administrative are taken up and decisions reached on how best to handle them. When there are sums of money involved, as in the planning of the Development Program, recommendations go to the Corporation Executive Committee. After agreement is reached the Corporation proceeds to look for the money to finance the improvements or changes. This procedure was followed after the war, when a special Corporation Committee took the report of the Administrative Council, studied it and the financial problem attached, and six months later completed the present plans for the development and expansion of M. I. T.

To put the plan into action, there is an administrative arm, the Building Committee, which makes decisions on space problems, selects architects and works out contracts. This committee has endeavored to spread the designing and construction assignments among as many concerns as possible. In addition to the Building Committee, which consists of the Executive Vice President, the Dean of Architecture, the Treasurer, the Provost, and the Superintendent of Buildings and Power, there is a Planning Committee, headed by the Dean of Architecture, which studies long-range building development and land utilization.

The buildings now springing up or soon to appear on the M. I. T. campus are all designed to fit a definite need occasioned by three goals of the Corporation and Administration. One of these major aims has been to improve the general environment at Tech and make the Institute more like a community of the nine thousand students and staff members in it. To avoid having this new community produce only human calculating machines, every effort is also being made to strengthen the work in general education — not only through the Humanities courses given in the curriculum, but through increasing emphasis on extracurricular activities and student self-government. A third and very obvious aim at Tech has been continuation of the pioneering in research which has been a mark of the Institute. It is M. I. T.'s plan to keep in the forefront of every field of scientific research.

By sometime next year, the Institute's campus should be graced with the beginnings of four new buildings, over and above the Hayden Library, the Wind Tunnel and the almost complete Hydrodynamics Lab and Naval Towing Tank building on Vassar Street.

Some time ago it was decided that, to produce competent metallurgists, it was necessary to bring together the designer, usually a mechanical engineer, and the metals man. To this end, a new program was developed, a man secured to head it, and the Metals Processing Lab opened within existing space. A new building is now needed for this program, and this summer Tech will begin the construction of 70,000 square feet of space in a new building on Vassar Street, which will eventually be remodeled. In addition, the Lab will include a remodeled version of the present plant used for foundry, welding and forging. The total cost of the project will be about one million dollars.

The Nuclear Science and Engineering Laboratory, under the sponsorship of seven interested departments at Tech, has as its purpose the advancement of research and training of qualified men in this now important field. The projected building for this research center will be situated as shown on the map and will provide 60,000 square feet of space in seven floors, two of which are below ground and well shielded. The Laboratory

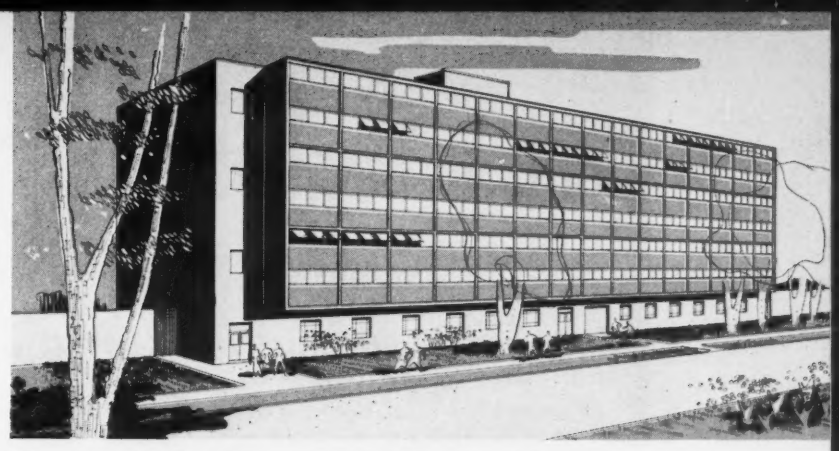
The new lab for Nuclear Science and Engineering will house research done by seven departments at M. I. T. There will be two shielded basement floors.

will also include the linear accelerator under construction along with presently operating particle accelerators. A field station, to contain larger equipment, is also planned. The new lab and the field station are estimated to cost two million and eight hundred thousand dollars, respectively, and for both there is a great need if Tech is to keep its research position.

The present Research Laboratory of Electronics is located in a temporary wooden building. If the space limitations of Building 20 were neglected, the fire hazard to the impressive and expensive equipment and research there would still make it necessary that the Lab be housed in a permanent building, estimated to cost over a million dollars. The Laboratory is jointly sponsored by the Departments of Physics and Electrical Engineering and is well known for its work in radar, although radar is only a part of its work. There are no immediate plans for the removal of Building 20, however.

Recently the newspapers have carried a large number of stories about new developments emanating from the Departments of Biology and Food Technology. However, important new grants for research are contingent on provision of adequate space and facilities. Much of the work of the second department is carried on in temporary buildings and that of the first in cramped quarters in the main building. Another 60,000 square feet in a new building is planned to house these departments. One feature of this new building will be flexibility in producing lab and office space as times require. With equipment, the new lab will run to about two million dollars. Construction should begin this fall.

There is much long-range planning going on so far as housing facilities at M. I. T. are concerned. The New Dormitory and the Riverside Apartments are only portions of the trend toward moving all undergraduate housing and recreational facilities to the west side of Massachusetts Avenue while the remaining space is used for educational purposes. Although a student union is in the planning stage for the West Campus, there is no definite time for the projected move to be completed. When all the undergraduates have moved west, however, it has been proposed that the living facilities near Ames Street be converted into residences

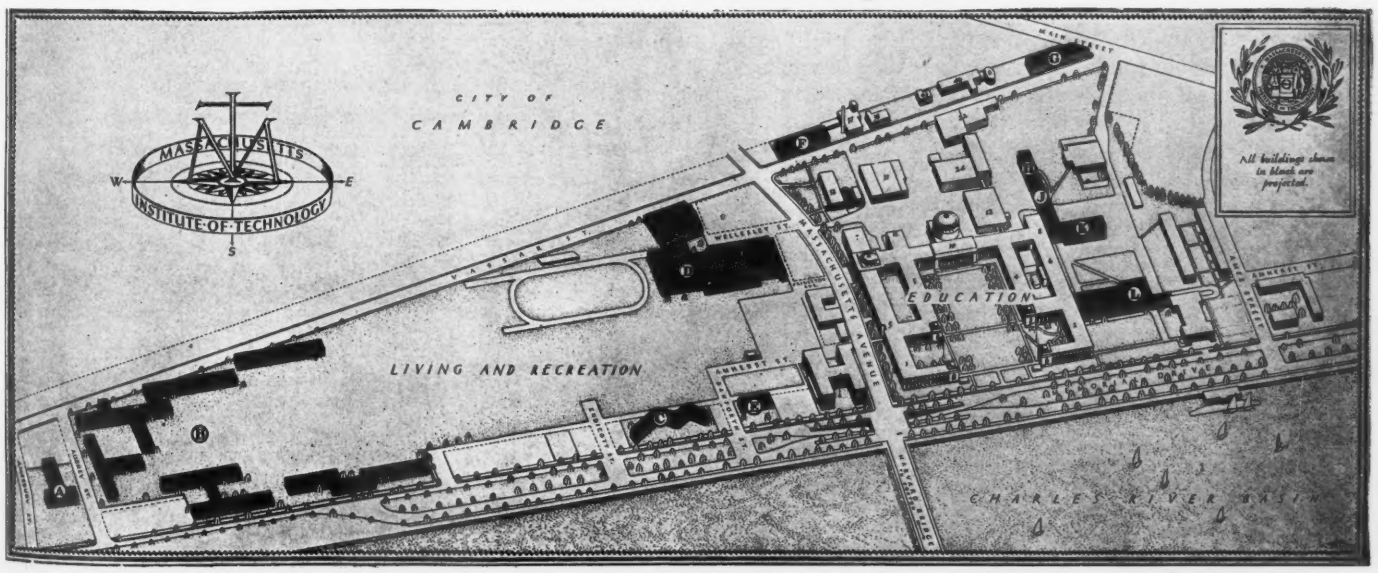


The new Metals Processing Laboratory pictured here will be on its way up this summer.

for graduate students. Walker Memorial would eventually become a building for faculty-graduate activities. This would fit in with the graduate and staff occupants of the near-completed Eastgate Apartments. Although the barracks dormitory will come down in the near future, Westgate should remain standing for some time, to be replaced with multi-storied buildings when it does.

A definite need on Tech's campus is an auditorium, in which might be given plays, concerts and convocations. It has also been suggested that a chapel be built. Although there are no definite plans in the present program for the chapel, a combination chapel and auditorium is being considered.

It is hoped and expected that, by sometime next year, the twenty-million-dollar Development program will have been completed and all new buildings planned either finished or well under way. Complete financing of the Metals Processing Lab, the Hydrodynamics Lab, and the Wind Tunnel has been achieved at this writing. Construction of new buildings is not begun until most of the funds required are on hand. Only in some cases is it possible for the Corporation to mortgage one of its buildings with other funds of its own, and only then when a fair interest rate on those funds can be paid. Gathering funds for some projects is somewhat complicated by the fact that most grants of any size come attached to specifications for their use. However, with the present program soon to be completed, M. I. T. will have insured both its leadership in research and its financial independence.



The Institute's building program includes:

A. Supersonic Wind Tunnel
B. Underclass Dormitories
C. Senior House
D. Gymnasium
E. Faculty Club
F. Metals Processing Lab
G. Hydrodynamics Lab and Towing Tank
H. Electronics Lab
J. Biology and Food Technology Lab
K. Nuclear Laboratory
L. Hayden Library

modern home design

New Ideas Make Progress in the Building Industry

By Bernard P. Spring, G.

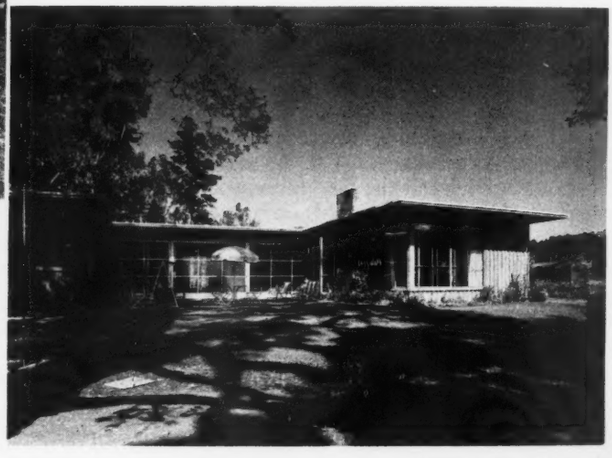
A start has at last been made along the road to an architecture which matches the basically changed living patterns of our age. Lately, even traditionally conservative speculative builders are yielding gradually to the influence of modern architectural ideas because they find houses suited more exactly to the needs of the present day family are easier to sell. It is a rare builder, however, who does not disguise his improved plan or construction behind a pseudo-colonial facade. Unfortunately, what was once a true expression of the technics of colonial building becomes nothing more than a stage set when built today and seriously compromises the livability of the house. Making full use of the enriched opportunities of modern life will inevitably mean a thoroughly revised expression of the house.

What are the principles which underlie this new kind of house architecture? Basically, they are very old. "Well building hath three Conditions, Commoditie, Firmness and Delight," said Sir Henry Wotton in the early seventeenth century, but even he merely paraphrased the Roman Vitruvius who two thousand years ago called for a workable plan, an efficient structure and esthetic delight in architecture. What *has* changed greatly through the years is the kind of life we lead and thus the kind of plan which can be considered workable; the kinds of materials and methods of construction mastered by man have likewise altered the kind of construction which can be considered efficient. It has been said that satisfying art has always resulted from honest, straightforward use of the knowledge and materials of an era, and the contemporary architect relies on creative fusion of the most effective planning and structural principles known today to produce visual delight.

Our increasing knowledge and control of the physical environment has thus become the prime force in chang-

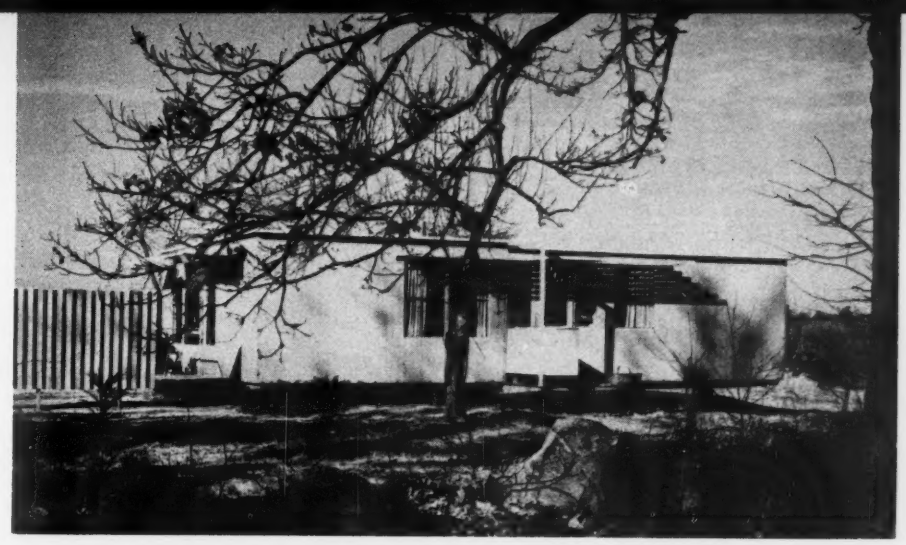
Above. **This house in Lincoln was designed by Tech Professors Lawrence B. Anderson and Herbert Beckwith. The two-story-high windows make it a remarkably open structure. The bedrooms at the sides are more enclosed with natural wood, blending in with the surroundings.**

Below. **Entrance side of the Hay house in Brewster designed by M. I. T.'s Professor Robert W. Kennedy shows how careful relation of house to site provides a fine natural setting for family life.** *P. A. Dearborn*



Roger Sturtevant Photographs

Above. **A house in California designed by Dean William W. Wurster of the Department of Architecture is organized about a pleasant outdoor living space which is intimately related to the interior.**



Industrially produced Acorn house designed by Tech Professor Carl Koch utilizes strong, light, machine-built walls, folds on built-in hinges for truck delivery to site. Lifting house completely free from ground simplifies foundation.
Ezra Stoller

ing the appearance of the house. The position of a house on a lot is no longer determined by abstract geometrical standards but by the most favorable exposure to the sun and winds. Today, the principal rooms of the house are placed so that the sun reaches them most of the time. The prevailing winds are studied so that they can be made to fall on relatively solid walls in winter while finding large open areas in summer. The climate, then, plays a major part in shaping the house, making it very open to the south and rather closed to the north.

Because people like the outdoors, the abrupt separation between the interior of the conventional house and its surroundings is being broken down. Now, the garden, even if it be a small one, can be developed into a living space which serves the family right along with the enclosed rooms. To facilitate the use of this outdoor living space, physical and visual nearness is increased by keeping the interior floor level close to the level of the ground and by providing large overlooking windows as well as an ample number of doors — often one from each room. Using the lot surrounding a house as an effective part of the living space helps counteract the lamentable reduction in floor area caused by rising construction costs.

We now have a great deal of sunlight pouring through our large windows and many doors. Once, it was thought that all this light would cause annoying eyestrain. The small windows of the conventional house glare uncomfortably when the sun streams through them and larger windows might heighten the problem. But it is not the quantity of light which causes discomfort, it is the magnitude of the ratio between the brightest and darkest values in a room. Thus opening a wall up with glass and eliminating the shadows caused by solid wall against the light leads to the most comfortable interior illumination.

In summer, when we appreciate the intimate relationship to the outdoors most, sunlight streaming through a wall of glass into our house is not a pleasant prospect. Venetian blinds or curtains cut off our view and can only stop the sun's rays after they are inside the space. But we know that the summer sun is higher in the sky than the winter sun and by letting the edge of the roof overhang the windows by a calculated amount, it is possible to stop the rays in summer while letting them penetrate deep into the rooms in winter when they become a fuel-saving source of radiant heat.

For most families, the house plan which depends on a staff of servants to keep it functioning is an impossible burden. Today, spaces must be kept compact and easy to maintain. In the pivotal position is the kitchen. The tortuous passageways which once separated the service areas of a house from the living

Above. **A steeply sloping, rocky site shaped the appearance of this Malden house by Prof. William H. Brown of M. I. T. Living and sleeping areas are closely related on top floor and can glimpse a view of Boston.**

Left. **Study of Professor Rapson's house in Chicago can be seen through fireplace which is used from both rooms. Outdoors becomes a dominating feature of these rooms.**

bookcases or screens, can serve to unite the family when they are engaged in varying individual activities or provide a large continuous area for group activity or entertainment. Built-in storage closets and drawers clear the floor of space consuming, hard to clean cabinets and chests. The appearance of the bedroom is most markedly affected by the use of built-in furniture. Cleared of excess furniture, it can more easily double as a daytime study or workroom.

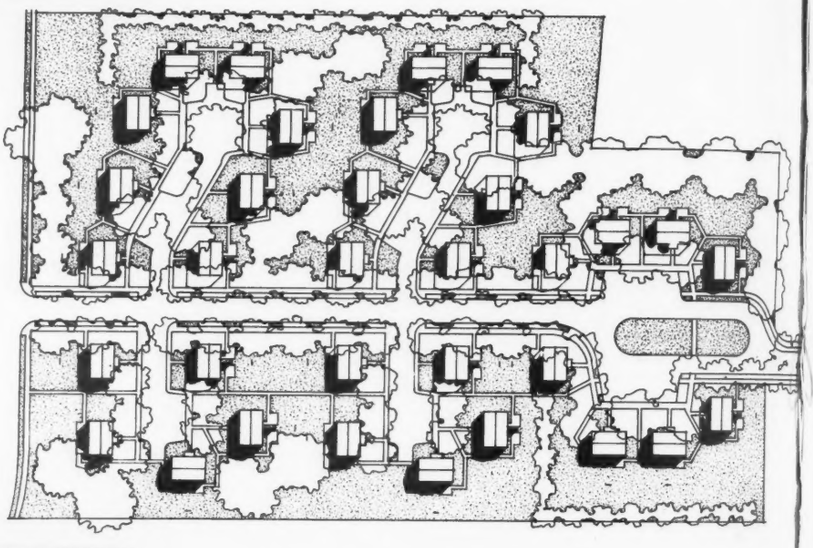
The past two decades have seen the average house shrink considerably in size while doubling in cost. First of all, our rising standard of living demands much more in the way of costly kitchen, plumbing, heating, lighting and other mechanical equipment. A family which must purchase all this equipment has little left for the structure of the house itself. The failure of the building industry, for the most part, to fully utilize

Above. **Interior of Professor Koch's Acorn house on the previous page. Note how dining area is closely related to kitchen by wall opening, to outdoors by large windows.**

Pictorial Services, Inc.

Right. **Improved appearance and useful outdoor living space is gained by grouping these thirty-two houses of Professor Kennedy's Peabody project around parklike areas rather than in rows.**

Below. **The Chicago house by Professor Rapson in heavily populated area has little land around it so terraces for living rooms and bedrooms above are incorporated into structure.**



area would now serve to separate husband from wife. Frequently when the kitchen becomes the hub of activity, the family loses the use of its own living rooms unless the kitchen is closely related to the rest of the house.

Seldom is it economically possible to provide and maintain a special room for each activity, but the new architecture turns this limitation to advantage. Replacing the traditional library, dining room, parlor combination is a single space made as flexible in use as possible. One generous room, partially divided by low

modern industrial methods of production, and the failure of building codes to allow new materials to be used have added considerably to the cost of enclosing space.

Efforts have been made by manufacturers to coordinate the dimensions of building materials, windows, doors and other elements so that the architect who adjusts his dimensions to a given modular grid can be assured of requiring only manufacturers' stock sizes, with corresponding economies. The regularity imposed by the modular dimensioning has been used by many architects to achieve a contemporary expression which harks back to the serene order of classic architecture. Others count more on the richness of simple, natural materials, joined in the most straightforward way to produce the economies as well as the warmth and variety needed for a living environment, but in every case the beauty of the house is inherent in the construction and not applied to it as an icing to a cake.

The conventional house wall is often composed of as many as twelve different layers of material, each applied by hand labor in the field. Today, the ideal of a thin, single-layer, machine-produced wall has been achieved. The new surfacing materials have had only experimental use but promise great economies accompanied by even more radical changes in the appearance of houses. Most of these light thin wall materials have only strength enough to enclose but not support the

(*Continued on page 22*)

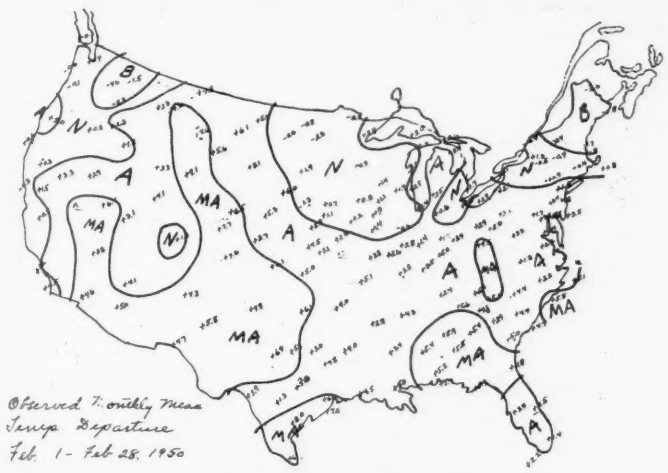
long-range weather forecasts

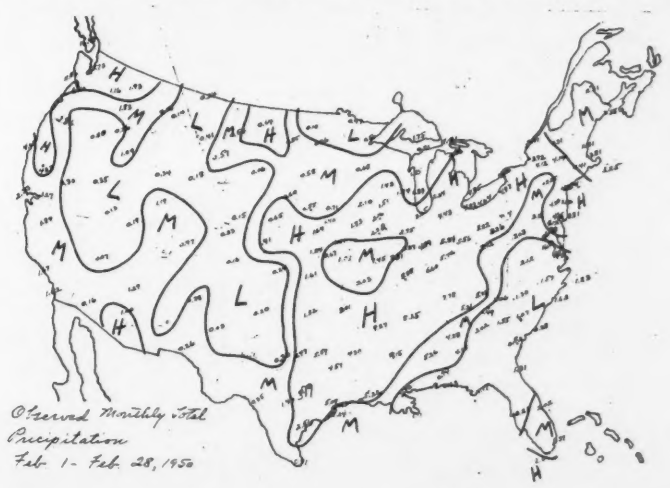
M. I. T. Weather Man Predicts Early Summer

By Sherwin Kalt, '53

Man's curiosity has always been stimulated by the seemingly unpredictable. Such curiosity may naturally be expected to become more urgent when a problem at hand is one which affects the life of each and every inhabitant of the earth. Meteorology, for this reason, would seem to be one subject which should hold some interest for every intelligent person.

Man may desire to predict weather conditions for one or a combination of two main reasons: the purely scientific, sometimes referred to as intellectual curiosity, or the more commonly encountered motivation, practicality. Would you like to know the chances for a warm





Above. A weather map used in long-range forecasting, giving the mean temperature departure for the month of February, 1950.

***Right.* A map for the same month showing total precipitation.**

afternoon the next time the Yankees come to Boston? You may wish a more accurate system of forecasting the coming of spring than that based upon the actions of our friend the groundhog. The Extended Forecasting Division of the United States Weather Bureau, in cooperation with the Meteorology Department at the Massachusetts Institute of Technology, is employing methods which can, within certain limits of accuracy, answer the type of question mentioned above.

The basis for the present system of long-range weather forecasts was developed at M. I. T. by Professor Hurd C. Willett and Jerome Namias, now head of the Government's Extended Forecasting Section, who, in 1940, succeeded in convincing the United States Weather Bureau of the usefulness of the methods. The following eight years were devoted to research, supported by the Department of Agriculture, aimed at the refinement of methods. Finally, in 1948, an experimental bi-monthly series of thirty-day forecasts was begun.

A number of methods are used to make these forecasts. The most important is the study of trends in the movement of the pressure systems which encircle the globe. The meteorologist realizes that certain semi-permanent conditions, such as the Bermuda high, exert great influence on weather throughout the Western Hemisphere. For instance, the expansion and advance of this system toward the North American coast would mean stable, clear weather for a large part of the United States.

In order to make long-range predictions, the forecaster must be able to determine the direction in which highs and lows are moving, the extent to which they are expanding or deteriorating, and their path during the coming month. To derive such information, the departments at M. I. T. and at Washington make detailed charts of the entire Northern Hemisphere showing extensive warm and cold air flows, barometric readings, and areas of precipitation. The forecasting staff then must determine the trend, or rate of change of weather conditions in large sections of the country. In order to insure greater accuracy, studies are then made of the rate of change of the trend. The forecaster then attempts to extrapolate this data as far into the future as possible. This study, although involving complex methods of statistical analysis in the compilation of maps and charts, is not basically mathematical, but depends for its success upon the experience and ability of the meteorologist in the interpretation of the information obtained.

Another method of reasoning sometimes used by the long-range forecaster is known as the system of analogues, which finds its use in a number of situations. This involves the compilation detailed maps as before, and the comparison with charts made in previous years. Often maps may be found which bear distinct resemblance to the current one in basic details. Predictions can then be made on the basis of developments shown under similar conditions in previous years. However, the technique exhibits certain fallacies which limit its use. It depends for its success upon the location of almost perfect analogues, and proceeds on the assumption that the line of development shown in previous situations will be repeated under approximately similar

(*Continued on page 26*)

statistics for industry

By Barry A. Stein, '53

It is unfortunate that the science,and it is a science, of statistics is so often looked upon by laymen as something to be strongly avoided. Most of us have undoubtedly used statistical analysis at one time or another, although we may not have realized it as such. The object of this article is to familiarize the reader with the more important measures and applications of statistics without going into the underlying theory.

Before it is possible to discuss application, it is necessary to understand something of the measures used in this type of analysis. Let us first look at our table of, say, observed values relating to the strength of single threads of yarn.

TABLE

Strength (oz.)	*Deviation*	*Deviation²*
7.4	− .5	.25
8.3	.4	.16
7.5	− .4	.16
8.0	.1	.01
7.7	− .2	.04
8.4	.5	.25
7.6	− .3	.09
7.5	− .4	.16
8.7	.8	.64
Total 71.1	3.6	1.76
Mean = 7.9		

One of the first measures that comes to our mind in analyzing a set of data is the simple arithmetical average; or, as it is known statistically, the mean. I think it is unnecessary to explain the meaning of this measure, but there are several others much more important which can be calculated from the given data. The most important of these is the standard deviation, which is calculated as follows.

$$\text{Standard deviation(s)} = \left[\frac{(\Sigma \text{ deviation from mean})^2}{\text{number of samples} - 1}\right]^{\frac{1}{2}} = \left(\frac{1.76}{8}\right)^{\frac{1}{2}} = .469$$

The square of the standard deviation is called the variance, and the coefficient of variation is defined as the ratio between the standard deviation and the mean, expressed as a per cent. The only other common method of expressing spread, or scatter, in a set of values is the range. For instance, the two sets of figures:

(a) 1, 3, 12, 9, 25, 4, 18, 16
(b) 13, 10, 8, 14, 11, 14, 9, 9

have the same mean, 11, but the range of (a) is 25 − 1 = 24, while in (b) it is 14 − 8 = 6. This, however, is not a good measure of dispersion. The larger the number of samples taken in a group, the more chance the range has of being misleading, due to the increased possibility of extreme values. The most important use of the range is in finding the average spread of a large number of small groups.

The significance of these and other statistical measures lies chiefly in their relation to the so-called normal distribution curve, which has a shape familiar to quiz-taking students.

For most sets of data, the curve approaches this, but it is necessary to realize that the term "normal" as applied to a curve of this form, is a technical term, and is not meant to imply that all data, if the samples are sufficiently large, approach closely, or at least approximate, this curve. The importance of this function lies in the fact that it can be completely defined in terms of the standard deviation and mean of a given set of samples. To illustrate, the mean $\pm$ 1*s* contains about 66 per cent of the total count, while the mean $\pm$ 2*s* contains all but five per cent of the total. It is, therefore, possible to calculate the probability that more than mere chance is causing the variation in a given set of data.

Another important property of the normal distribution is that it can be used to relate the different measures of central tendency and those of spread. There are three important measures of centralness, or central tendency, of a group of figures. One of these, the average, is already familiar to the reader. The median is defined as the middle value in a set of figures, while the mode is the most common value. As an example, consider the series: 3, 4, 7, 4, 6, 4, 2, 4, 4, 5, 4. The median is 4.5, since the series goes from 2 to 7. As you can readily see, the median is closely related to the range. The mode, on the other hand, is four, since that is the most frequently recurring value. In a normal distribution, the mean, the median, and the mode are identical. The relationship between the mean deviation, standard deviation, and range is as follows:

(1) Mean deviation = .798 × Standard deviation.

(2) Mean range of random samples, each of *n* units = *Dn* × Standard deviation, where *Dn* is a constant depending on the value of *n* for its value.

Up to now we have considered various measures which can be applied to various sets of data. Suppose, however, that we wished to find the equivalent measures of the entire population from which the samples originated. This obviously can rarely be done by direct measurement of every segment, particularly in textiles, where most tests are of a destructive nature.

The easiest way to do this is to infer that the original sample closely approximates the entire population. However, in this case it is necessary to develop some method of determining the accuracy of the final result. One of the most popular of these significance tests is the so-called *T*-test, which is based largely on the fact that the accuracy of the inferred data is proportional to the size of the sample.

To illustrate the *T*-test, let us assume that we desire to find out whether or not the difference between the mean strength in the above table (7.9) and the theoretical mean strength (8.0) which we actually desire is statistically significant. We therefore apply the *T* formula, which is:

$$T = \frac{\text{Difference between mean and theoretical value}}{\text{Standard deviation}\left(\frac{1}{\text{number of items}}\right)^{\frac{1}{2}}}$$

(*Continued on page 28*)

stresscoat

By Howard F. Davis, '53

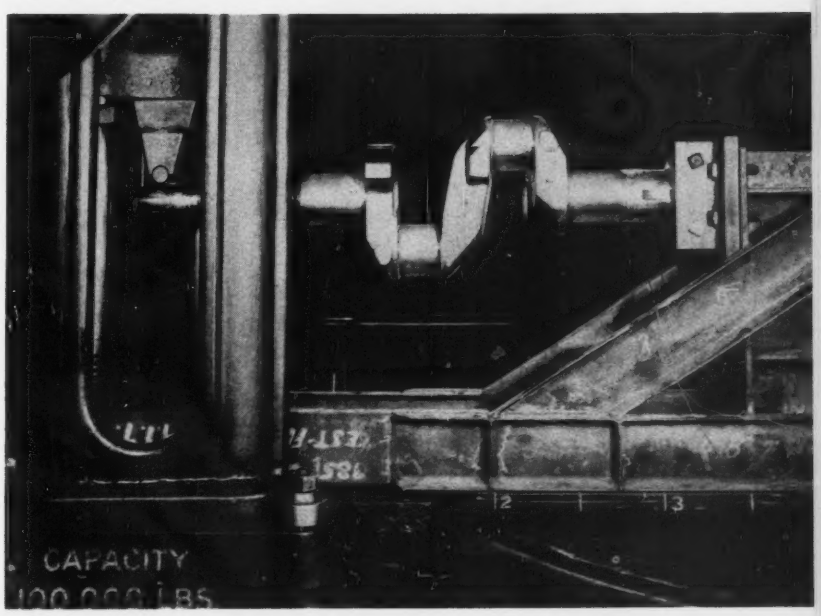
Experimental stress analysis is an old art; however, the developments within the last decade have overshadowed many of the previously standard methods in this field. These developments consist mainly of brittle coating, strain gauges, and photoelastic stress analysis. Each of these is most advantageously applied to a specific field, and with the combination of them, experimenters are able to cover thoroughly a very wide range in stress analysis. Because of the great number of problems that are unique to each of these instruments it is necessary to treat them separately.

The principle of brittle coating has been known for a considerable time; however, when it was first introduced, and for a long time after, it could be used only to locate sections which were under high stress, near and beyond the elastic limit of the material. Therefore it was a difficult task to develop it so that it could be used in analytical work.

The principle in which brittle coating is used in experimental stress analysis is that a coating on a stressed body cracks in lines perpendicular to the direction of maximum strain in the body. The great advantage of this is that it is true for a body of any shape or size. In an effort by experimenters to apply this principle the problem was to find a coating that would give quantitative results under reasonable conditions. This problem is more complex than the principle on which it was based. Of the numerous coatings developed it has been found that the one most applicable to stress measurement is brittle resin dissolved in a lacquer.

Brittle coating is used because of the ease with which it can be applied. It is sprayed on the body instead of dipping or brushing because a more uniform layer can be obtained, because of the speed with which it can be applied, and because the odd characteristic that the bubbles in the coating make is more accurate in quantitative measurement than those of coatings without bubbles.

It was found that the patterns formed by the stressed coating are most easily studied if the background has a uniform color. So in most cases aluminum pigmented undercoating is applied to the surface before the brittle coating. This background also aids the experimenter to determine the thickness of the coating, because it is necessary to have it distributed evenly over the surface. The background under normal conditions will dry in fifteen minutes.



The stresses on the test body should be observed within its elastic limits, and at constant temperature in clean surroundings.

Another aid to the quantitative accuracy of brittle lacquer is a red-dye etching material composed of a solvent concentrated with organic dyes. It is used when the cracks in the stressed coating are not distinct, and when they close after the load has been released, as in dynamic stresses where the pattern cannot be observed while the forces are acting. The dye seeps into the cracks to color them red.

A cantilever calibration bar is the instrument with which it is possible to obtain quantitatively the stresses in a body. The calibration bar and the test body are lacquered at the same time, and kept under the same temperature and humidity. When the lacquer has been allowed to dry for about 18 to 24 hours the two bodies are stressed. The cracks caused by unknown stresses in the test body occur at different loadings, with the cracks appearing first at the sections under highest stress. To determine the stresses on the test body that cause the initial cracks, the calibration bar is stressed with known forces until the initial cracks appear on it. Thus, knowing the stresses causing the initial cracking on the calibration bar, it is possible to calculate the stresses causing the initial cracking on the test body. Then if the test body is put under greater strain cracks will appear at a number of positions on it. Then the calibration bar is stressed until a corresponding number of sets of cracks appear on it. From this data it is possible to calculate the stresses at various positions on the test body.

In dynamic loadings a number of grades of stress coats are used until the one is found such that any

(*Continued on page 30*)

next step—zero!

By John Mathis, '53

Since the beginning of his stay on earth, man has been faced with the problem of dealing with variations of temperature, but only comparatively recently has he turned from a desire to reduce his discomfort due to heat and cold to a scientific study of the effects of temperature variations on the materials of our world. While some methods of artificially producing low temperatures, such as freezing mixtures of ice and salt, have been known for hundreds of years, the lowest temperature obtainable in 1714 was used by Fahrenheit as the zero mark on his temperature scale. Now scientists are investigating phenomena at temperatures as far below Fahrenheit's lowest mark as the temperature of a hot stove is above it.

The conquest of the lower ranges of the heat scale has required the hard work of many scientists. Not until Faraday's discovery that combined cooling and pressure can liquefy a gas and Joule and Thompson's observation that the expansion of a gas produces a cooling did practical ways of attacking the problem present themselves. When effective refrigeration machines were produced in the 1870's, however, work on low temperatures progressed rapidly. The "permanent" gases, nitrogen and oxygen, were liquefied in 1884, and by the turn of the century hydrogen had been condensed at 21° K., or −252° C. In 1908 the liquefaction of helium, the last gas to succumb, was finally accomplished by the use of solid hydrogen under low pressure.

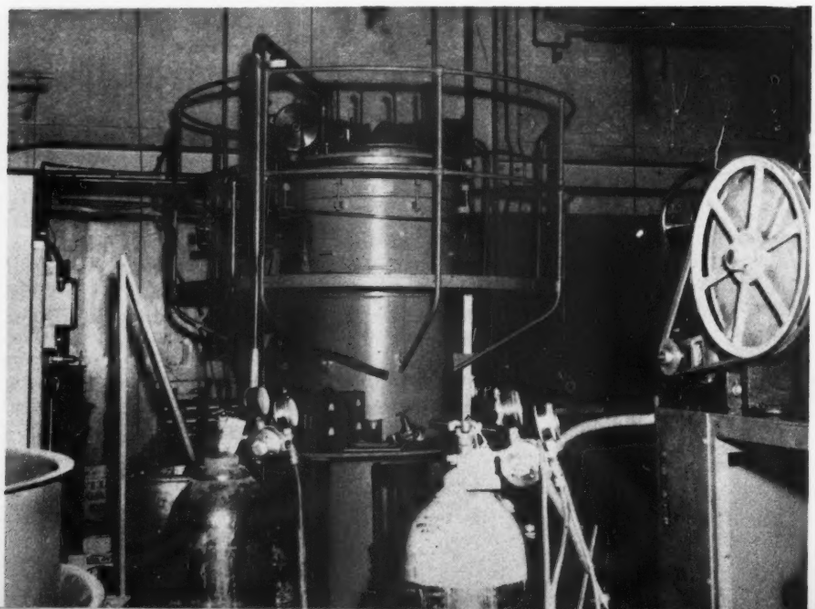
Liquid helium soon became available to scientists in sizeable quantities. Many investigators began to determine the behavior of matter at very low temperatures. Startling discoveries were not long in appearing. When the Dutch scientist H. K. Onnes made a routine determination of the electrical resistance of mercury, at 4.26° K. he found an astonishing departure from the expected relationship of resistance to temperature. At this point the resistance abruptly vanished; a change of one-tenth of a degree decreased it ten thousand times. The value of the resistance was not even measurable at lower temperatures. Onnes had discovered the perfect conductor of electricity.

Practical men as well as scientists were interested in this discovery, for a perfect conductor would mean savings of thousands of dollars in power transmission. Many workers tried to discover a material which would become superconducting at ordinary temperatures. Almost every known metal or alloy was tested, and a total of seventeen superconducting elements were gradually discovered. Many nonmetals were tried, and a few revealed superconducting properties. However, further investigation of superconductivity revealed that its application to power transmission is impossible because it cannot occur in a magnetic field stronger than a certain low critical value. Tests showed that currents would be necessarily confined to a few tenths of an ampere or less, for the magnetic field created by a larger flow would destroy the superconductivity. The dreams of those who wanted almost costless power transmission were rudely shattered by this fact.

Nevertheless, scientists continued to discover unusual properties of superconducting substances. They found that a current set up in a ring of a superconductor will circle the ring apparently indefinitely. The transition interval from the ordinary state was also found to be amazingly small. The resistance of very pure tin drops to zero within one ten-thousandth of a degree, and other superconductors have comparable intervals. The transition point was always found to be very low; one of the highest is that of columbium nitride at 10.1° K. In view of the present cost of liquid helium, this low transition temperature makes application of superconductivity impractical.

At the transition point some other physical properties of a superconductor abruptly change. The specific heat of a metal increases slightly but discontinuously, and the conductivity of heat seems to be irregularly changed by low temperatures. However, there are no changes in density, coefficient of expansion, or other properties. There is still need for further investigation of changes in structure at the transition point.

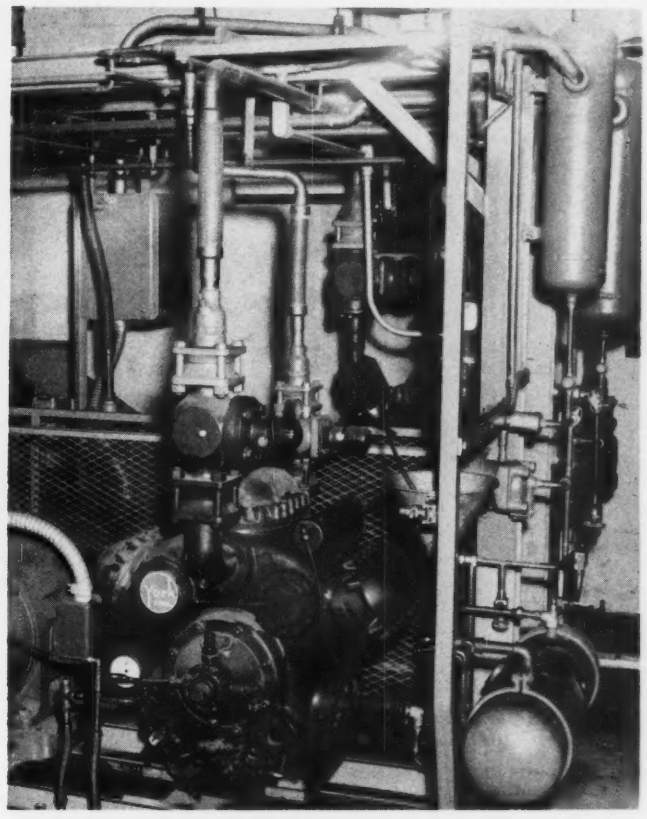
But what happens to helium, the only liquid at absolute zero, when the temperature goes downward? When the clear liquid helium at 4.2° K. is subjected to a reduced pressure, it boils furiously at first, then slowly, and finally lies completely quiet and motionless. It is almost impossible to see the surface unless the tube is shaken a little. When the temperature drops to 2.19° K., however, part of the liquid begins to change



The partially completed Collins Cryostat with surrounding cylinders of helium.

Left. **Lab assistant inspecting large Dewar flask used to store liquefied gases. Apparatus in background is for thesis work.**

Below. **A view of the compressor used in cooling helium from room temperature to 4° K.**



invisibly into a superfluid possessing properties of no other substance known.

This superfluid, called helium II, refuses to be bounded by ordinary liquids' limitations, such as viscosity and confinement to containers. For all practical purposes, its viscosity is zero. It is so fluid that it will easily pass through bacteria filters that keep ordinary helium out. The pyrex walls of silvered Dewar flasks are too porous for this Houdini, for it quietly but quickly seeps through the minute holes in the glass and destroys the heat-insulating vacuum. It further defies the rules of etiquette for liquids by running freely through the finest capillary tubes under no net pressure. It seems immune to the ordinary laws of physics.

Not content with flowing through the walls of its containers, superfluid also climbs over them. Unperturbed by gravity, a thin film of superfluid will creep up the walls of its container at a speed of some 15 cm/sec. If the bottom of an empty test tube is placed in the liquid, the liquid runs up the outer wall, over the top, and slowly fills the tube to the outside level. If the tube is raised from the surface, the film now creeps up the inside, down the outside, and drips off the bottom of the tube. The rate of flow depends not upon the difference of the inner and outer levels, but solely on the perimeter of the vessel in contact with the superfluid. The only way of stopping the film's advance is to raise the temperature of the fluid above the transitional 2.19° K. in order to change the superfluid into the more ordinary liquid helium that cannot creep up vertical walls.

Another way in which superfluid helium exhibits unconventional behavior is its ability to conduct heat several hundred times as fast as any metal. A short tube with small holes at each end provides another striking demonstration of liquid helium's unusual behavior. One end of the tube is packed with fine emery powder and dipped into liquid helium. When a light is shined on the emery powder, a jet of liquid several centimeters high will spout out the upper orifice in a small fountain. In an open tube, the effect is sufficient to raise the inner level of the helium about one centimeter above the surrounding surface. Contrary to what one would expect in normal fluids, the upward surge is greatly increased by decreasing the diameter of the capillary spaces through which the helium must flow. The only function of the emery dust is to provide fine spaces in order to increase the pressure.

Although the connection is certainly not obvious, the phenomena of conductivity and the unusual properties of helium II appear to be related. However, the exact nature of superconductivity is open to great debate and is still a most difficult theoretical problem.

The structure of liquid helium, however, is better understood. While not scientifically correct, it is convenient to picture superfluid helium as a varying mixture of two components; one, an ordinary liquid like the liquid helium above 2.19° K., and the other a superfluid stable at 0°. Varying the temperature from 2.19° to 0° forms superfluid in increasing proportions. Even if it is not rigorously acceptable, this idea of a mixture of two liquids at different temperatures is useful in explaining the properties of helium II.

The superfluid component has no viscosity and flows toward heat independently of pressure. There is a constant equilibrium between the two components; when an energy source converts the superfluid into ordinary helium, more superfluid must flow in to maintain the equilibrium. In the fountain experiment, flow of superfluid toward the energy from the light increases

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tech engineering news

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from the editor's notebook

Actual *vs.* Theoretical...

Almost everyone who has been a freshman at M. I. T. will agree that the ratings of 6-0 (6 hours per week in class, no preparation) for Descriptive Geometry, a freshman course which is useless to a great many students, and 3-0 for Military Science, are unreasonable. The person is very rare indeed who will take a quiz in Descriptive Geometry without having spent many hours in preparation after class. A similar situation exists in the case of Military Science. For instance, as part of the map reading section of this course, the student is given five pages of symbols to memorize. The extra time which must be devoted to such supposedly "no homework" courses would be better spent assimilating the concepts taught in the more essential and basic sciences.

This situation definitely needs adjustment. At present there appear to be two possible solutions. These "minor" courses might be drastically revised to eliminate in practice the necessity of extra study. However, such a move would force the omission of certain topics which might be essential to some professional courses. Another solution would seem to be more logical: The freshman course should include nine hours of electives. Descriptive Geometry and Military Science should be made optional, as they are in other schools. This would allow only those who want the subjects to take them. Furthermore, the ratings, in hours, should be adjusted to accurately represent the time which must be devoted to these courses. It would seem illogical for the Institute to allow this great difference between hours spent and credit given to go uncorrected.

—Sherwin Kalt.

St. Patrick's Day...

It occurs to us that St. Patrick's Day at Tech passed without so much as a raising of a (non-Irish) eyebrow. It seems that this is a unique situation among engineering schools, for a perusal of the magazines of some reveals a widespread custom of connecting engineering and this particular saint. He is acclaimed the Patron Saint of Engineering by virtue of some obscure hieroglyphics unearthed in Missouri, which were interpreted to mean exactly that. Of course the result of all this is: Celebration of the Event. Mammoth dances, parties, queen crownings, etc. take place — all of which goes to show that anything goes as an excuse for fun. Perhaps the M. I. T. Chapter of the Sons of Erin will pick this up.

Good Idea...

It's too late to do us any good, but the Institute has decided to undertake re-education of high school science teachers. Fifty of them will arrive at Tech July 5 for a six-week training period under the sponsorship of Westinghouse. Is this not a good thing? Plainly so, for though such a program can't hope to make substantial additions to the teachers' knowledge, it can stimulate them and release them from the stagnation of routine public school teaching. Result: a few more interested teachers, which means many more interested students.

Sound Off!...

By the way, we are going to have a letter column to facilitate the articulate sounding off by our readers on our errors, shortcomings and omissions. If you have anything nice to say, we'll print that too. It is hoped that the more prolific of the letter writers can be drawn into the Lit staff for regular duty. So start thinking about it over the summer and try to have your comments in for the October issue. Seriously though, letters on anything at all are welcome, and those we can't print will be sent to *VooDoo*.

—G. B. F.

(*Continued from page 7*)

to the crystal due to the on-off cycle of the thermostat. By means of such construction and careful adjustments on the thermostat it is possible to obtain a temperature control in the crystal chamber which is five times more accurate than the sensitivity of the thermostat itself.

At present, the temperature to which the crystal is held is 60° C. ± .05° C. With further experimentation and adjustment, it will be possible to control the temperature to approximately ± .01° C.

Following the crystal oscillator which operates at 100 kilocycles is a string of four multivibrators, each dividing its control frequency by a factor of ten except the last one which divides it by two. The 50 cycles thus produced is amplified by a tuned 50 cycle amplifier. By choosing proper values of grid and screen resistors for this amplifier, it was possible to obtain exactly 115 volts at 50 cycles from it, thus satisfying perfectly the requirements of the clock.

When this clock was first tested a year ago last March, its frequency remained within two parts in ten million of a standard frequency during the first day. This, however, was with a new crystal and very poor temperature control (in comparison to the present temperature control system). Now that the crystal is a year old and therefore more stable, and the temperature control system has been improved, the clock's accuracy has undoubtedly improved. At present, when this clock is accurately adjusted against standard time from the National Bureau of Standards, it requires approximately five days before there is any noticeable difference (about $^1/_{10}$–$^1/_{15}$ of a second) between the time indicated by the clock and standard time. This indicates a day by day accuracy of approximately .01 to .02 seconds, or in other words, its frequency over a period of a few weeks never varies more than one or two parts in ten million. Therefore, the frequency of the current leaving the 50 cycle amplifier is always within 0.00001 cycles from 50 cycles!

The most accurate frequency standards in this country are those of the National Bureau of Standards. Frequencies which are transmitted from WWV, the radio station of the National Bureau of Standards, are accurate to within two parts in one hundred million (2×10^{-8}). These standards are, however, themselves compared by astronomical means with the rotational period of the earth, which therefore is our real standard of time and frequency.

This standard, however, is far from the ideal because the earth is very gradually slowing down due to the forces of tidal friction. Besides this, there are many irregular and sudden variations in the period of rotation for reasons which as yet remain unknown. Because of these factors, the determination of the rotational period of the earth to a much greater accuracy than one part in one hundred million (1×10^{-8}) is impossible or impractical.

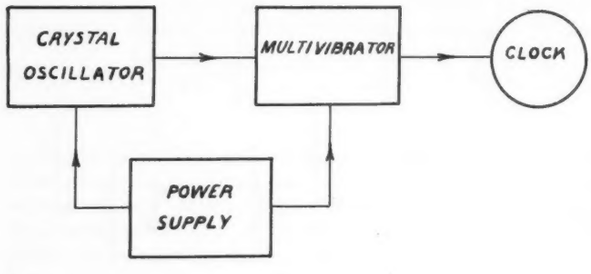


Figure 1

In recent years it has been found that many gases absorb radio waves of a particular frequency, or band of frequencies, any one gas always absorbing at the same wavelengths. Thus it became apparent to scientists that, if a means of utilizing one of these absorption lines to control clocks could be developed, then a standard of time and frequency would be found independent of astronomical determinations.

The atomic clock or a form of it may sometime become the invariant standard. The first such clock ever built, controlled not by a crystal but by a waveguide containing ammonia gas, had an accuracy of one part in ten million. True, this is about ten times the error in our present standard, the rotating earth, but theoretical considerations indicate a potential accuracy of one part in a billion or ten billion, depending on the type of atomic system and spectrum line used.

A simplified block diagram of the atomic clock is shown in Figure 3. The signal is originated by a 100 kilocycle oscillator, similar to those used in precision clocks, but not necessarily as accurate. This frequency is then multiplied by means of standard radio tubes, klystrons and silicon crystal diodes to approximately 24,000 megacycles, one of the frequencies at which ammonia absorbs energy. This microwave signal is compared, by a suitable control circuit, with the line in the ammonia spectrum. If the spectrum line and the microwave signal do not agree, a discriminator circuit, part of the control link, generates an error signal. The error signal is then applied through proper circuits to the oscillator, forcing it to the proper frequency. By means of multivibrators like those used in crystal controlled clocks this frequency is then reduced to any desired frequency for running a clock.

Figure 2

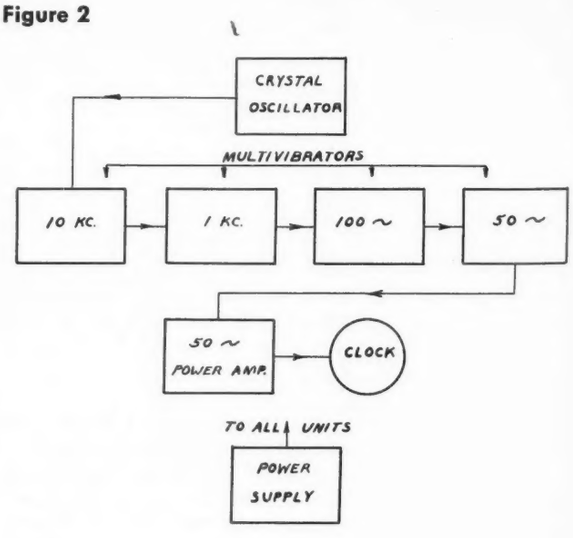
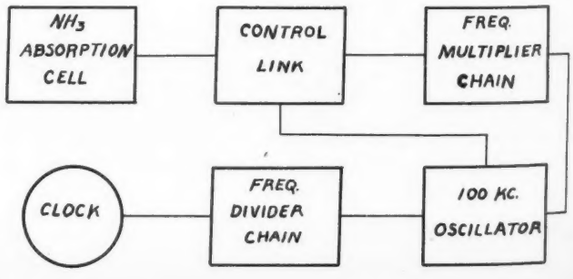


Figure 3



What would your chances be...
in case of a HOSPITAL FIRE?

In case of fire, your chances might not be too good in many hospitals today.

Each day there are *three* fires of record in hospitals and institutions, and in those where fatalities occur an average of *five* lives are lost per fire! Isn't this proof positive that many trusted precautions are not adequate protection at all?

Unfortunately, too many people responsible for protection rely completely upon the elimination of ordinary fire hazards, important as this is. All too many more depend upon "fireproof" construction. Two facts show this to be false confidence: "Carelessness with matches and in smoking" continues to be the greatest cause of fires . . . and so-called "fireproof" buildings continue to become furnaces for flammable contents.

What most people ignore is that, regardless of the cause of fire, regardless of the building construction, it is the *proper control of fire from the first spark that constitutes full and adequate protection against fire.*

Needless loss of life and property can be prevented by checking fire at its source, whenever and wherever it starts, night or day, automatically, with a Grinnell Automatic Sprinkler System. Seventy years experience shows that practically 100% of fires starting in buildings protected by Grinnell Automatic Sprinkler Systems are extinguished before doing material damage. Fire experts will tell you that your best protection against fire in any building is automatic sprinklers.

LOOK FOR THE GRINNELL SPRINKLER HEADS ON GUARD

In hospitals, as well as in hotels, theaters and factories, there is a moral obligation upon management for the utmost in protection of life. For your own sake ask about it in your hospital or the hotel where you stop, the schools your youngsters attend, the plant in which you work. Everywhere, look for the famous Grinnell Sprinkler heads — your assurance of positive fire protection. Grinnell Company, Inc., Providence, Rhode Island.

GRINNELL

FIRE PROTECTION SYSTEMS

ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL

Interior of the Lincoln house on page 12 by Professors Anderson and Beckwith. Note the light, sunny outlook on the nearby woods.

modern home design

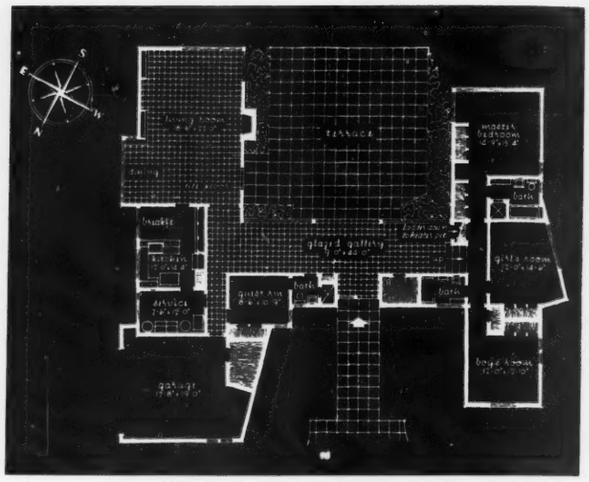
(*Continued from page 12*)

house. The supporting function will be transferred entirely to a fine skeleton of beams and columns with walls acting merely as skin. This type of construction reduces the actual and apparent mass of the house until the volume of the enclosed space becomes the dominating visual feature. There is indeed a radical difference between the older concept of a building as a sculpturesque mass set in space and the new lightness of thin walls and spatial volumes which flow through the house and out into the surrounding gardens.

Complete industrialization of the house building process has been considered by many to be the only practical answer to the economic squeeze play on today's house. A number of attempts have been made at complete factory production of dwellings. There have been brilliant solutions to the design and production problems involved but the difficulties of finance and distribution have been, as yet, insurmountable.

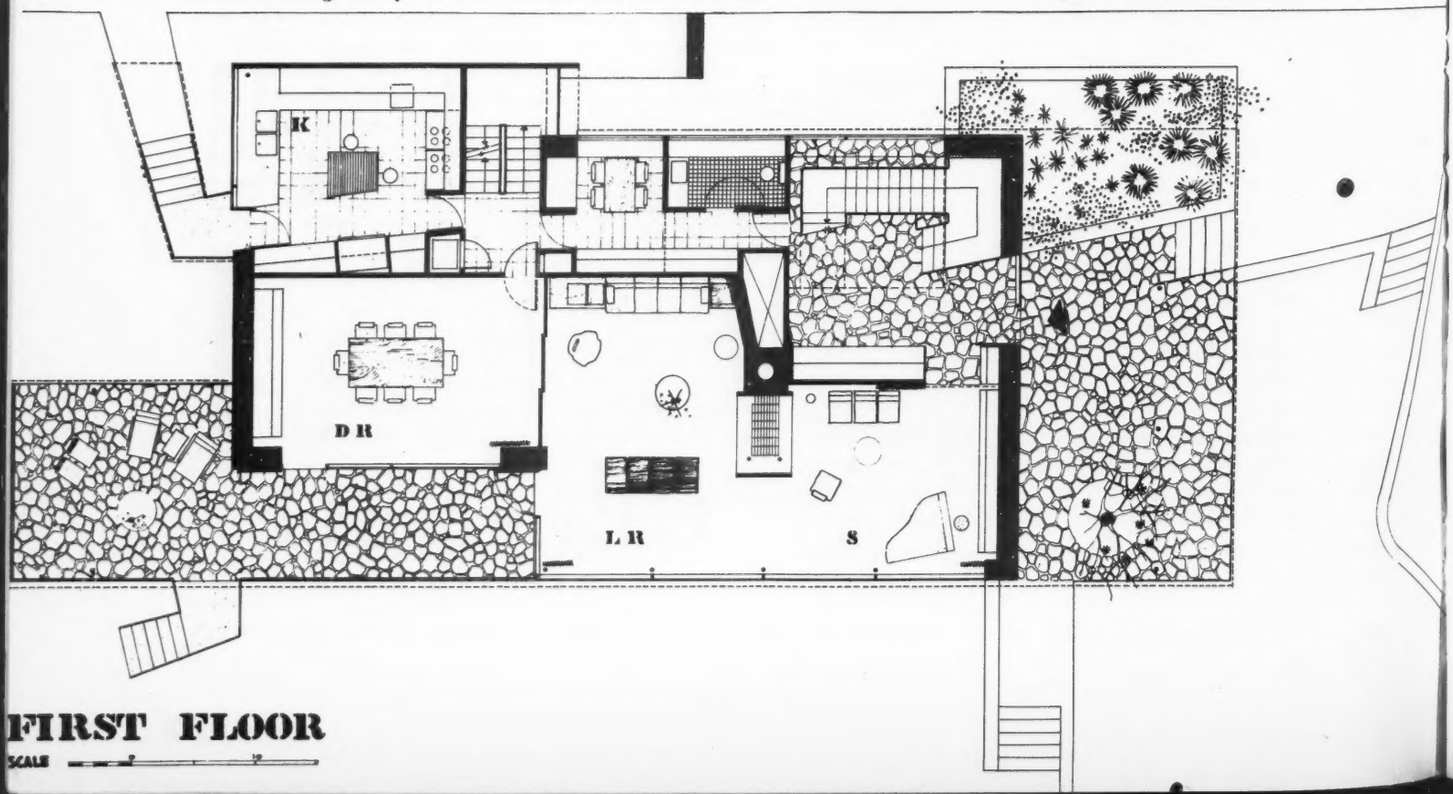
Great concern has been expressed lest the industrialization of housebuilding lead to excessive regimentation and drabness in our communities. You don't need to industrialize houses to produce these conditions. Speculative builders have managed for years to line up row upon monotonous row of like structures, and have done it using costly field labor and outmoded handicraft methods. For the modern industrialized house as well as for the custom-built or speculator-built modern house, the relationship of the building to the site on which it stands and to its neighboring houses becomes a vital part of the planning process. The old pattern of houses in rows lining either side of a street is immediately broken up when we face our buildings to the sun and cool summer breezes. Now, with living

(*Continued on page 24*)



Above. **Plan of Dean Wurster's house appearing on page 10. It has rooms disposed so that as many as possible get southern sunlight. Living spaces flow into each other; are separated from sleeping area by gallery.**

Below. **Plan of Chicago house by Prof. Ralph Rapson of M.I.T. indicates how study, living, and dining areas form a single space which is modulated by the fireplace and sliding doors. Living area extends out onto paved outdoor terraces.**



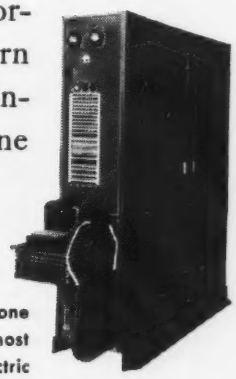
Newsworthy Notes for Engineers

To improve the accuracy of testing Bell telephone switching equipment and to speed up tests during manufacture, Western Electric engineers designed and built a unique test set—known as the Tape-O-Matic—which has a paper tape "brain."

Controlled by a narrow paper tape, punched with coded information, the machine *automatically* performs complicated series of tests. If there is a fault in the equipment under test, the Tape-O-Matic stops, rings a bell and indicates the source of trouble on a lighted panel.

Some 1200 different tapes, varying in length from one to thirty feet, are used for testing various assemblies. Formerly an operator, in testing an average size assembly, had to make 41 individual connections. With the Tape-O-Matic, one multiple plug connection does the job. And 28 preliminary tests, 81 lamp observations and 71 key operations are replaced by one tape insertion and the push of a button.

The Tape-O-Matic can cut testing time as much as 80%—practically eliminates the possibility of human error—and helps to assure equipment of highest quality. It is a good example of the ingenuity, skill and thoroughness which Western Electric engineers put into making Bell telephone equipment.

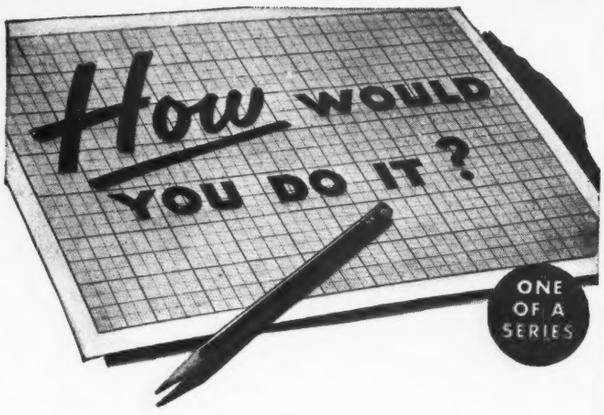


The 1500-pound Tape-O-Matic is one of the largest, most complex and most versatile test sets that Western Electric engineers have ever devised.

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

Engineering problems are many and varied at Western Electric, where manufacturing telephone equipment for the Bell System is the primary job. Engineers of many kinds—electrical, mechanical, industrial, chemical, metallurgical—are constantly working to devise and improve machines and processes for production of highest quality communications equipment.



PROBLEM—You are designing a cabinet-type oil heater. The oil and air metering valve has to be placed at the bottom. You now want to provide a manual control for the valve located on the cabinet front where it is easy to see and to operate. How would you do it?

THE SIMPLE ANSWER—Use an S.S.White remote control flexible shaft to connect the dial to the valve or to a rod running to the valve. The latter method was used in the heater illustrated below. The flexible shaft will provide smooth, sensitive control and will allow you to put the dial anywhere you want it.

Photo courtesy of Quaker Mfg. Co., Chicago, Ill.

★ ★ ★

This is just one of hundreds of power drive and remote control problems to which S.S.White flexible shafts are the simple answer. That's why every engineer should be familiar with the range and scope of these "Metal Muscles"* for mechanical bodies.

*Trademark Reg. U.S. Pat. Off and elsewhere

WRITE FOR BULLETIN 4501

It gives essential facts and engineering data about flexible shafts and their application. A copy is yours free for asking. Write today.

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
DEPT. C, 10 EAST 40th ST., NEW YORK 16, N. Y.
FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

One of America's AAAA Industrial Enterprises

Closeup of Professor Brown's Malden house shows simply constructed overhang for protection from summer sun.

modern home design

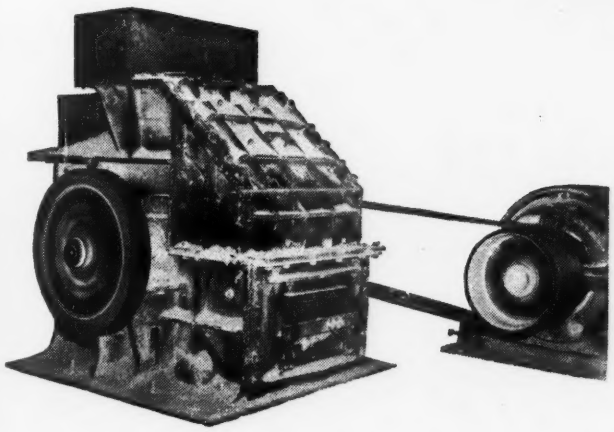
(*Continued from page 22*)

spaces opening boldly into gardens, we want privacy and separation from traffic. Overlooking the street might have been a pleasant diversion in the days of leisurely horse-drawn carriages, but today it is merely a source of noise and danger. Without the need of presenting a formal facade to the street, our house can now be placed on the most favorable part of the lot; it can be shaped to fit in with the existing slopes and planting. If large areas are planned before any building takes place, houses can be placed so that they group informally about interior parklike areas which provide children and adults alike with a protected recreation space away from the traffic of the service roads, now in the rear.

It is not only the individual house to which the newly developed ideas outlined above apply. The city apartment house, in its own way, can have the flexible, flowing spaces, orientation and sun control, improved mechanical equipment, new structural methods and materials, good relation to site and neighboring buildings that the single family house has. The Eastgate

(*Continued on page 28*)

Another page for **YOUR BEARING NOTEBOOK**

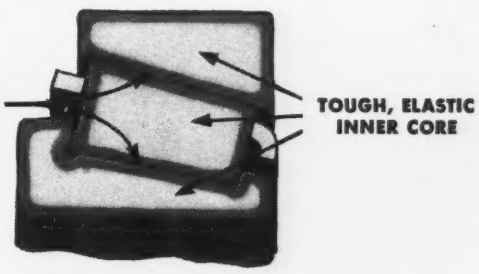


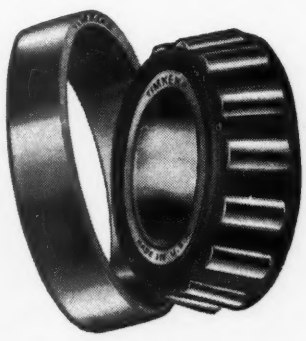
How to keep a rock crusher from minding the grind

In a hammermill rock crusher, every revolution of the rotor shaft puts a heavy shock load on its bearings. Engineers have solved this problem by using Timken® tapered roller bearings. Timken bearings take the heaviest loads—both radial and thrust. They require a minimum of maintenance and normally last the life of the crusher.

Why TIMKEN® bearings can take the tough loads

In Timken bearings, the load is carried on a *line* of contact between the rolls and races, instead of being concentrated at a single point. Made of Timken fine alloy steel, rolls and races are case-carburized to give a hard, wear-resistant surface with a tough inner core to withstand shock.





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TAPERED ROLLER BEARINGS

Learn more about bearings!

Some of the engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'll be glad to help. For additional information about Timken bearings and how engineers use them, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL ⊙ AND THRUST ⊙ LOADS OR ANY COMBINATION ✳

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Engineering leaders for the last 81 years have made K & E instruments, drafting equipment and materials their partners in creating the great technical achievements of America. So nearly universal is the reliance on K & E products, it is self-evident that every major engineering project has been completed with the help of K & E.

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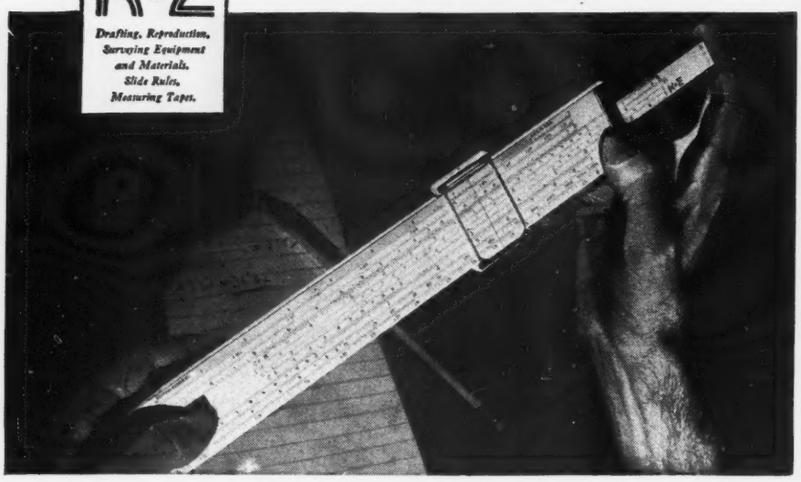

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QUICK QUIZ ON INSULATED CABLES

Q. What process for coating copper conductors is superior to "tinning"?

A. Okoloy coating on conductors in rubber insulated cables outlasts "tinning" 2 to 1. Okoloy -- an exclusive alloy developed by Okonite -- is more resistant to corrosion than tin and prevents reaction between copper and rubber. Years of use prove that it has twice the life of "tinning." It's one more reason why Okonite wires and cables are so reliable, so truly economical to use.

THE OKONITE COMPANY, PASSAIC, NEW JERSEY

THE BEST CABLE IS YOUR BEST POLICY

OKONITE insulated wires and cables

8032

long-range forecasts

(*Continued from page 13*)

conditions. The obvious pitfalls to this theory make it one which can only be applied in special cases and under the supervision of experienced analysts.

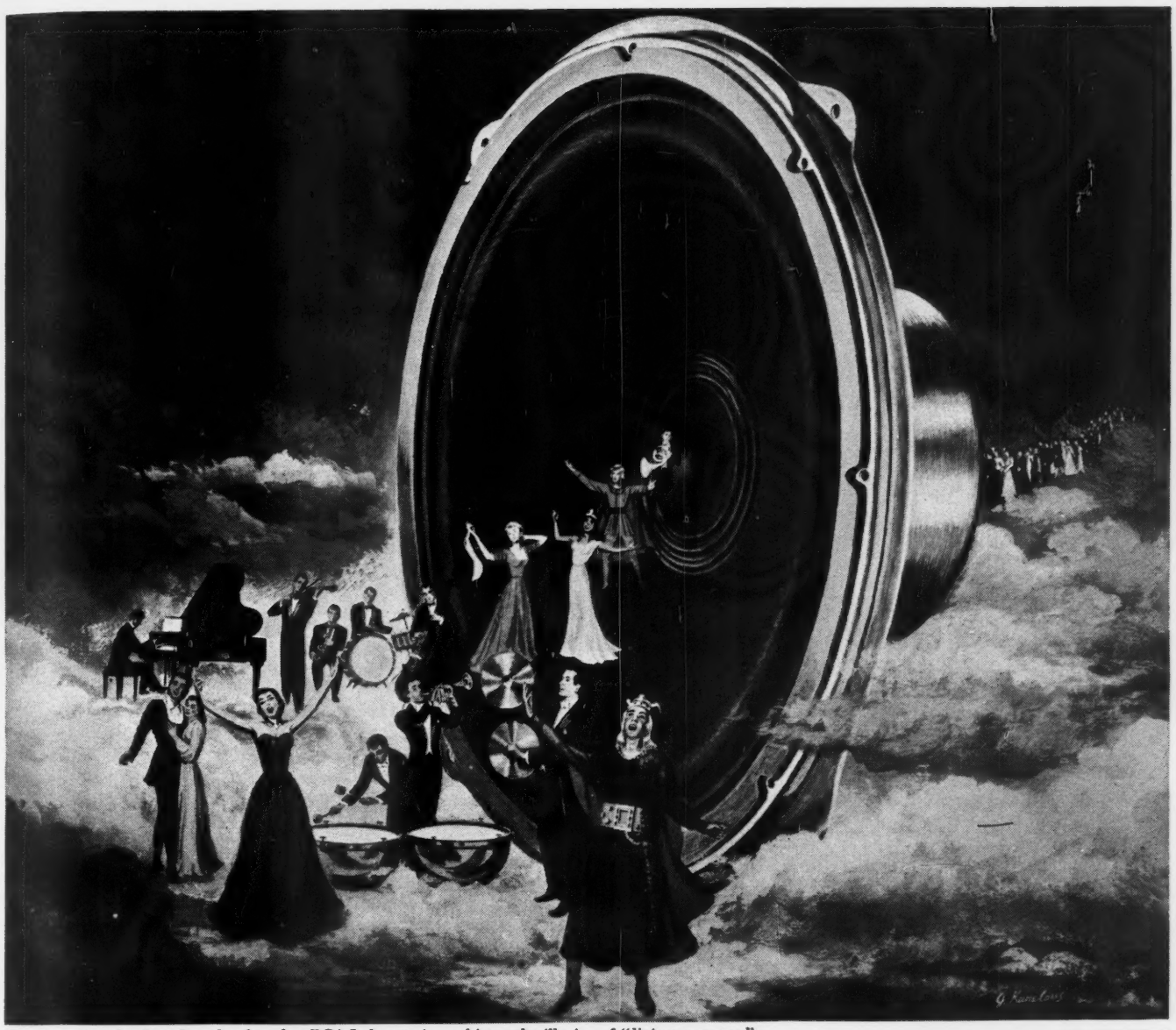
Recently, a third method of prediction gained some publicity in the daily newspapers. This is an idea which has appealed to many men throughout the years. The theory is predicated on the hypothesis that weather conditions are governed by a definite number of variables which may be combined into a complex set of equations. Once this is done, observations could be plugged into these formulae, which, with the aid of calculating machines, would produce accurate long-range forecasts. Newspaper reports state that such a method has been developed by the United States Air Force in Germany. However, although the Air Force admits that research is being done in the field, no scientific papers have as yet been published to clarify the methods.

Be that as it may, the meteorology departments at M. I. T. and at Washington will proceed in the perfection of the methods already in use. At present the department at M. I. T. is engaged in a study to determine the effect of weather conditions in South America upon patterns in the Northern Hemisphere. Data is radioed and telegraphed to M. I. T. Here maps and charts are drawn to correlate the information pouring in from observers in both hemispheres. This study will provide a basis for inclusion in long-range analysis of readings obtained from our neighbors down South. Up to the present time, the "lower" half of the globe has been largely ignored, which undoubtedly is one cause of much of the inaccuracy experienced during the last year and a half. It is expected that this more complete coverage of the global weather situation will result in an improvement in the Government Division's record of 65 per cent accuracy.

The function of the M. I. T. Meteorology Department is mainly research of the type outlined above. The only official government long-range forecasts are issued by the Bureau at Washington and mailed to subscribers twice monthly. (The charge for this service is $4.80 per year.) However, in addition to its major occupation, the laboratory at M. I. T. issues monthly extended forecasts which cover weather conditions in the Northern New England States. These predictions are of interest to many corporations in the area for a number of reasons. Since the forecast is confined to a more limited area, it can be made more accurate than otherwise would be the case. In addition, the M. I. T. forecasts are issued for a period of two months instead of the usual monthly predictions.

On March 22, just before this article went to the printers, the forecast for Northern New England was sent to subscribers. The letter promised "cool weather continuing through a good part of April, and a moderately wet period extending from the latter part of

(*Continued on page 32*)



New Duo-Cone loudspeaker, developed at RCA Laboratories, achieves the illusion of "living presence."

Music lovers' "horn of plenty"

For years, working toward the ultimate in sound reproduction, scientists have sought for *living presence*—the illusion that a musician or speaker is talking, singing, playing in your home.

Now, with RCA's Duo-Cone loudspeaker, the goal is achieved. Two sound-cones in acoustical alignment reproduce sound without distortion, and give you every tonal value from a frequency of 30 on to 15,000 cycles. It is in the area above a frequency of 4,000—seldom touched by conventional speakers—that most of the all-important "overtones" lie. RCA's Duo-Cone loudspeaker reproduces every overtone—to the very peak of a violin's range—and faithfully gives you the deep low notes of a bass drum!

In addition, the RCA Duo-Cone loudspeaker's wide angle of sound pervades every corner of a room without sharply directed blast or blare. Its response to tones of every frequency is smooth, flowing, and even.

* * *

See the newest advances of radio, television, and electronics at RCA Exhibition Hall, 36 W. 49th St., New York. Admission is free. Radio Corporation of America, Radio City, N. Y.

Continue your education with pay—at RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short wave and FM circuits, television, and phonograph combinations).
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- Design of component parts such as coils, loudspeakers, capacitors.
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- Design of receiving, power, cathode ray, gas and photo tubes.

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RCA

RADIO CORPORATION of AMERICA

World Leader in Radio—First in Television

statistics for industry

(*Continued from page 14*)

Substituting the actual values, we have:

$$T = \frac{8.0 - 7.9}{.469\sqrt{1/9}} = \frac{.1}{(.469)(.332)} = .623$$

The process of evaluating this figure depends on a table of calculated figures representing the probability that the difference is significant, depending on the number of degrees of freedom: this latter usually meaning the number of items minus one. Most of the T tables are made out for the two major significance levels: five per cent and one per cent. The value of five per cent has been arbitrarily chosen as the limit below which a reasonable certainty of significant difference exists. There are three general rules which are regularly followed in evaluation of this probability.

(1) If the numerical value of T is less than that of the 5 per cent level, the difference is not statistically significant. I might take this opportunity to point out that as the probability of significance increases, the value of T also increases.

(2) If the numerical value of T lies between the 5 per cent and the 1 per cent levels, there may be a real difference, but this is by no means conclusive.

(3) If the value of T falls inside the 1 per cent level, act as if a significant difference exists.

These are by no means exact rules, but as a general indicator, they are useful.

Upon looking up in a table the values of T for $9 - 1$ or 8 degrees of freedom, we find that the 5 per cent value of T is 2.306. Since this is so much higher than .623, we can safely conclude that there is no evidence which indicates that a significant difference exists, and therefore we can disregard the difference.

Beside the T-test, there is one other test of significance in general usage, called the F-test. This cannot usually be substituted for the T-test, as its function is entirely different. It is mainly used in situations where it is deemed advisable to compare two machines or outputs in order to determine whether or not a significant difference exists. The test iself is extremely simple, consisting merely of the ratio of the variances, or standard deviations squared, of the two samples being compared.

As an example, suppose that a set of yarn twist tests is made on each of two different machines, A and B. Eleven samples are chosen at random from A, and seven equally at random from B. Let us further assume, and more will be said about this later, that it is known from previous experience that machine B sometimes gives greater twist than machine A, and we desire to test whether or not this is true in the present case. The variance expected to be greater is always the numerator (in this case, B), since the test is only applicable when F exceeds unity. We have found that the standard deviation of A is 1.31, while that of B is 2.85, and therefore we can set up the simple equation:

$$F = \frac{\text{Variance}_B}{\text{Variance}_A} = \frac{(\text{Standard deviation}_B)^2}{(\text{Standard deviation}_A)^2}$$

$$= \frac{(2.85)^2}{(1.31)^2} = 4.73$$

To determine the meaning of this figure, we must consult a table of the values of F which, as before, indicate the 5 per cent and 1 per cent significance levels, and are based on the degrees of freedom of samples A and B, which in this case are six and ten. The table lists 3.22 as the 5 per cent level and 5.39 as the 1 per cent level. Since our value of F falls between these two, we can say that there is some evidence of a significant difference, but not conclusive, and further tests should be made.

It is also possible to use the F test for a single standard deviation, if we know from past experience what the other standard deviation should be, or has been. The formula in this case is exactly the same as in the previous test.

If prior knowledge concerning the factors being considered exists, the probability of a significant difference is doubled, both in the T- and in the F-test. However, the F tables are calculated for use with prior knowledge, so that if none is known the 5 per cent and 1 per cent limits become the 10 per cent and 2 per cent limits, respectively. On the other hand, the T tables are calculated for use without any previous knowledge, meaning that if any exists, the 5 per cent and 1 per cent limits become the 2½ per cent and ½ per cent limits, respectively.

In the preceding sections, I have stated that the standard deviation and variance of a set of data were important measures, but the variance itself has another extremely important property which has not previously been mentioned, namely, that the variance is additive. In other words, if the variation in a sample is due to two or more factors acting separately, the total variance is equal to the sum of the participating variances: *i.e.*,

$$S_1^2 + S_2^2 = S^2_{\text{total}}$$

This property of course makes it possible to estimate the relative importance of a number of contributing factors to the problem under consideration. The field of statistics concerned with this and related functions is known as the analysis of variance but unfortunately this is beyond the scope of this paper, and therefore we will not discuss it here.

Almost all of our industries show the characteristic tendency of uncontrolled variation in output quality. It is this characteristic which makes statistical method so well suited to an industrial civilization such as ours.

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modern home design

(*Continued from page 24*)

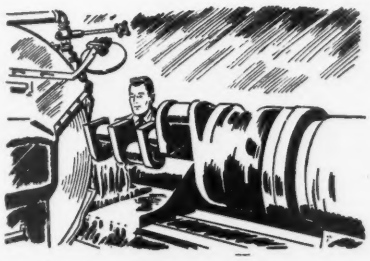
apartments are a first-hand demonstration of many of these new concepts. (See *Tech Engineering News*, December, 1948.)

Modern architecture as we know it is still in its infancy; the men who launched it are alive today. When we look back and see how many generations of development it took to produce a mature gothic architecture in the Middle Ages, the size of the task ahead becomes apparent. Because of the newness of the modern ideas, many financial institutions have, until now, hesitated to give the needed support to the construction of modern homes. This has been the main drawback to more widespread use of our vital contemporary architecture. The success of the first experiments and the growing support of the people who have seen and understood the richness that a modern home can contribute to family life, is creating a hopeful atmosphere in which the new architecture can flourish.

How Edwin Peterson might answer his 7-year-old son Paul. Edwin knows the answers. He's been around Norton for 30 years. In fact, ten percent of Norton employees have been on the job 25 years or more.

"GEE, DAD, WHY DOES IT HAVE AN UPSTAIRS?"

"To make traveling more fun. The idea is to give people more to see and do while riding faster and safer. That means more passengers for the railroads so that they can keep fares down and still add more comfort to long trips."



"Railroad comfort comes from many things, son. Smooth-fitting parts are important. Parts like Diesel engine crankshafts, pistons and wheels. That's why so many railroad shops use Norton grinders and Alundum grinding wheels to make parts smooth.

"Take those side rods on steam locomotives. They get farther over on the smooth side thanks to Norton internal grinding wheels. And parts are finished so accurately with Norton quality controlled wheels that they last for thousands of miles, Paul.

"Getting back to comfort . . . modern trains travel over 60 miles an hour. So, they need smooth rail joints. Those joints are welded for safety. Then, they're ground smooth and slotted with Norton grinding and cut-off wheels."

"Hundreds of other parts of modern railroad trains and tracks also get a lift from the sure touch of Norton Products. So does just about any other product you can name. That's why I'm not boasting when I say that Norton makes better products to make other products better."

NORTON

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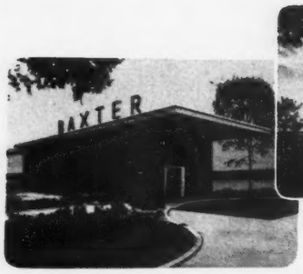
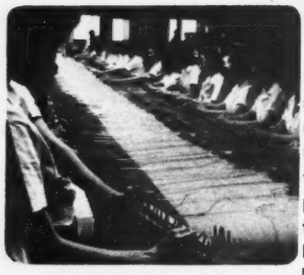


Office and Plant are Modern Throughout

New Pharmaceutical Laboratories Air Conditioned with Frick Refrigeration



Assembling Expendable Transfusion Sets

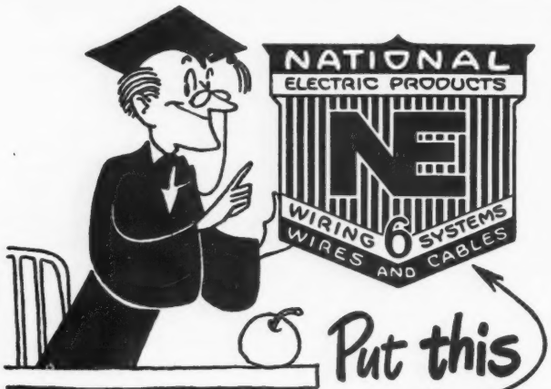
Baxter Laboratories, which have the largest production of intravenous solutions and blood transfusion equipment in the world today, use two Frick NEW "ECLIPSE" compressors for cooling the offices, research departments, and many work areas in their recently completed plant at Morton Grove, Ill. This covers 300 by 400 ft. Frick installation made by Midwest Engineering and Equipment Co., Sales Representatives in Chicago.

Two Frick NEW "ECLIPSE" Compressors

The Frick Graduate Training Course in Refrigeration and Air Conditioning, Operated over 30 Years, Offers a Career in a Growing Industry.

FRICK CO. — Dependable Refrigeration Since 1882 — Waynesboro, Penna. U.S.A.

Also Builders of Power Farming and Sawmill Machinery



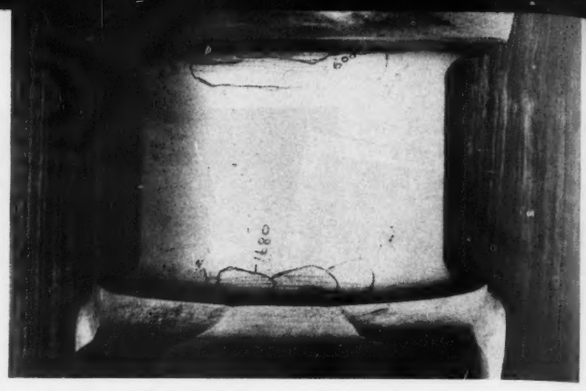
Put this name in your note book!

Sometime you'll be looking for something racy in raceways. Or you'll want asbestos cable that really beats the heat. National Electric has all that plus everything else you'll want in the way of a *complete* line of electrical roughing-in materials. Everything in the field of wires, cables, conduit, raceways and electrical fittings.

NE has been the symbol of quality for more than 45 years.

National Electric Products Corporation
Pittsburgh 30, Pa.

NE is a good name to remember.



A casting under stress showing cracked coating.

stresscoat (*Continued from page 15*)

lower grade would not form a pattern and any higher grade would form too many patterns. The stress on a gun at the time of firing is typical of dynamic loading; the stress patterns form immediately when the stress of the coating is reached.

The initial cracks in the coating at a point are the ones of importance, because after getting a few sets of cracks, further strain would cause cracking over the entire body. If there is relatively small stress the cracks will take no definite pattern; however, with further loading the haphazard marks straighten out into definite patterns.

Coatings have been developed so that it is possible to measure 0.0005 to 0.005 strain. This corresponds to the 15,000 psi to 150,000 psi on steel. Although it is not quantitatively accurate it is possible to find stresses as low as 100 psi on steel, and to detect stress on such brittle material as glass without exceeding the elastic limit.

The organic dye mentioned previously is also useful in increasing the sensitivity of the brittle lacquer. If this dye etchant material is put on while the system is under stress the coating will become more sensitive by a strain of 0.0006. That is if the coating was originally calibrated at a strain of 0.0009 it would become sensitive to 0.0003 strain. The principal stress can be found by multiplying the principal strain by the elastic modulus; therefore, the highest accuracy is obtained if the stresses are either pure tension or compression. With an experienced operator results will be around 10 per cent accurate. To get an accurate measurement of the stresses at a specific point a strain gauge or strain rosette is used; however, to get an overall picture of the stresses on a body with strain gauges is a long and tedious task.

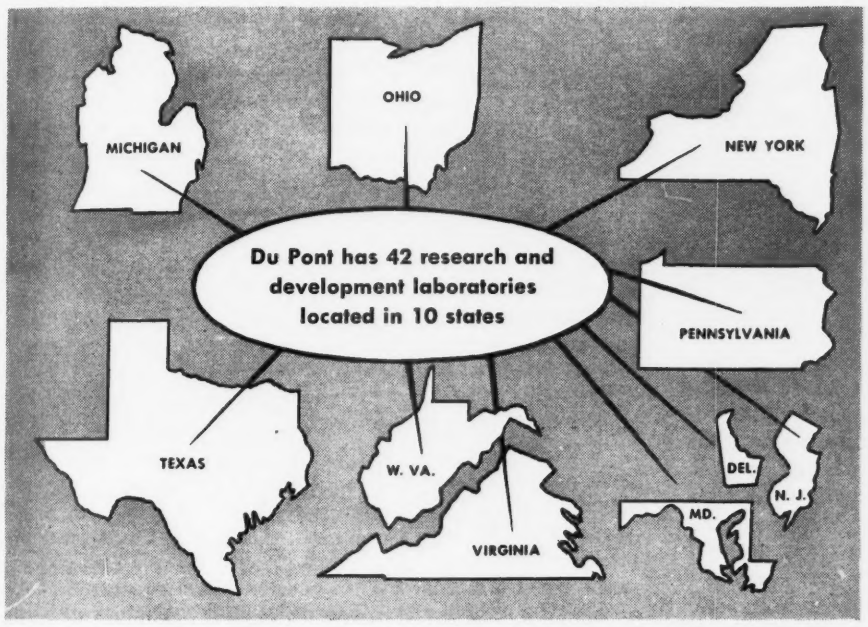
The major drawbacks to brittle coating are the need for experienced operators, and its sensitivity to temperature and humidity changes. As a result the temperature must not vary more than 5° F. during the loading. It is because of this that it is necessary to have a variety of coatings which can be used at desired temperatures. There are about ten grades of brittle coating — with these it is possible to determine within the previously mentioned range the strain at any constant temperature between 50° and 100° F. This property of stress coat does not prevent its use in determining thermal stresses, because it has been found possible to determine accurately the effects of thermal loadings by replacing them with static stresses.

The application of brittle coating covers an exceedingly wide range. To mention just a few of the many places it has been used with success: on moving parts such as connecting rods and automobile engine fans; on parts that must withstand impact such as guns and airplane landing gear; and on materials that have considerable residual stress.

THE DU PONT DIGEST

RESEARCH DECENTRALIZED

Du Pont scientists pursue their studies from Buffalo, N. Y., to Orange, Texas



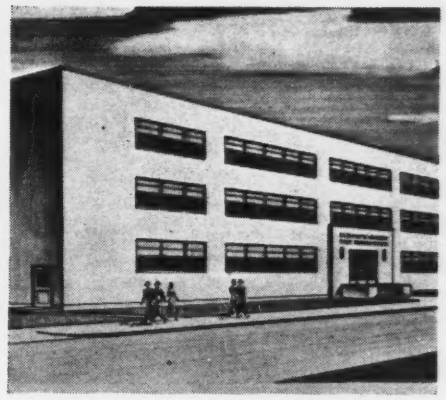
THE DU PONT COMPANY is a large company. Its many manufacturing plants are now located from Maine to California. Likewise, the Company's research activities are spread over a wide area. From the Founder's informal scientific experiments on the Brandywine have sprung 42 research and development laboratories in ten states.

Each manufacturing department* has its own research director and maintains facilities for studies in its specialized fields. Thus, research having to do with dyes, neoprene and fine chemicals is centered at Deepwater, N. J.; research on cellophane and other transparent wrapping films at Buffalo, N. Y.; research on viscose rayon at Richmond, Va.; and research on coated and impregnated fabrics at Newburgh, N. Y. These are only a few of the places where Du Pont scientists are now at work. Each manufacturing department does fundamental research as well as applied research on new processes and products.

Many types of training

At any one time, many hundreds of different projects are under way in these laboratories. Though a relatively large number of Du Pont technical people are chemists and chemical engineers, other fields of training are strongly represented.

Among the scientists working with Du Pont are mechanical, electrical, civil, industrial, mining, petroleum, textile, architectural and safety engineers, physicists, metallurgists, biologists and mathematicians. About 30% of these men and women who are engaged in technical activities at Du Pont hold doctor's degrees.



Artist's drawing of the Marshall Laboratory, new Du Pont laboratory for research on finishes. Under construction at Philadelphia, it should be ready for occupancy by late 1950.

Interchange of thinking

All manufacturing departments may draw on the services of the chemical, engineering and toxicological laboratories of the company in Wilmington. In addition, the Chemical Department's library at the Wilmington Experimental Station circulates reference material, conducts literature and patent searches and issues a weekly abstract of pertinent articles found in the important chemical journals of the world. This supplements normal work of this kind done by the various manufacturing departments.

No matter where a Du Pont research man may work, he has every opportunity to use his best talents, to advance as his abilities develop, and to profit by interchange of thinking with scientists whose minds complement his own.

**There are ten Du Pont manufacturing departments —each conducting research: Electrochemicals; Explosives; Fabrics & Finishes; Film; Grasselli Chemicals; Organic Chemicals; Photo Products; Pigments; Polychemicals; Rayon.*

★ ★ ★

SEND FOR "This Is Du Pont," 52 pages of information on Du Pont's methods, products, facilities, geography. Fully illustrated. For your free copy, write to the Du Pont Company, 2503 Nemours Building, Wilmington, Delaware.

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BETTER THINGS FOR BETTER LIVING
... THROUGH CHEMISTRY

Great Dramatic Entertainment—Tune in "Cavalcade of America" Tuesday Nights, NBC Coast to Coast

next step—zero!

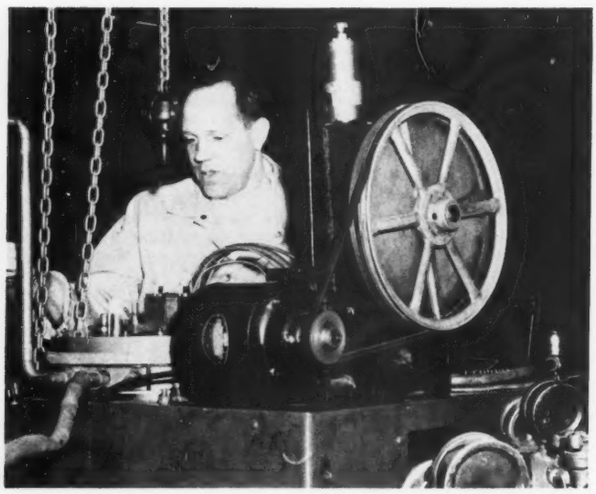
(*Continued from page 17*)

the internal pressure of the tube and is responsible for the fountain.

The migration of the superfluid component towards a heat source is responsible for another phenomenon in helium II. When a small heat source is placed in the fluid, an accumulation of the superfluid builds up around it. When the heat source is removed, the normal and superfluid components flow toward each other in order to maintain the new heatless equilibrium. Their momentum causes them to pass through each other in waves resembling those of sound. These waves, instead of consisting of a series of rarefications and compressions like sound, are composed of a succession of ordinary liquid helium and colder superfluid travelling in opposite directions. They exhibit sound's properties of reflection and reverberation.

The many restrictions for a substance to become superfluid eliminate everything but helium. A chemically inert atom is required because high intermolecular forces prevent freedom of movement. Hydrogen does not become superfluid because its single unpaired electron forms molecular bonds. Also, due to a strange condition of symmetry of structure, only an atom with an even number of atomic particles can become superfluid. The light isotope of helium, He^3, has five particles, three in the nucleus and two outer electrons, and hence does not become superfluid, while the ordinary He^4 has six particles and does exhibit unusual properties. This is the most striking case where isotopes of the same element have radically different physical properties.

While fairly low temperatures, about 0.7° K., can be produced by evaporation of liquid helium, another means must be used to go lower. In order to accomplish this, a so-called para-magnetic salt, like potassium chrome alum, is placed in a liquid helium bath. This salt has the property of giving off heat when placed in a magnetic field and absorbing the heat when the field is removed. The liquid helium takes up the heat produced when the field is turned on. When the field is removed, the salt absorbs heat from its surroundings. When the salt is lifted from the bath before the heat is removed, the temperature of the crystals has been made to drop down to .0029° K. This opens a whole new region of temperature below 1° that is unattainable by evaporation methods.



Professor S. C. Collins at work amongst his cooling equipment.

What does a modern low temperature lab look like? The laboratory at Tech shares a large, high-ceilinged, barnlike room with the linear accelerator. The wooden partition dividing the two projects runs down the sixty-foot length of the room and is lined with green cabinets that are arranged to partition off three small work spaces. There is an air of activity about the whole place; cylinders of helium, pipes, tubes, and flasks lie about in seeming confusion on several small tables within the work spaces. Overhead pipes run along the ceiling. The passageway down the length of the lab seems narrow because of the experiments along each side.

In each of the spaces partitioned by the lockers there are several silvered Dewar flasks held in place by clamps and connected to rubber hoses and tubes. The open lockers display more pipes, joints, and copper connections. Electrical equipment is crowded onto the tables. Cylinders of gas are stored in corners. Working space seems to be the critical item.

Farther down the laboratory are the cryostats, or liquid helium machines, developed by Professor Samuel Collins of M. I. T. The one in present use is a square boxlike machine with copper tubes and pipes protruding from the open top, and dials and switches adorning the front panel. This machine can produce about four liters of liquid helium per hour.

Beyond this machine the grey cylinder of the new, almost completed cryostat. It looks like a large tank about eight feet high and five feet in diameter that has a handrailed walk surrounding its top. Meters and other gadgets are attached to its sides. When completed, the cryostat will greatly aid the lab by producing twenty liters of liquid helium per hour.

Instead of attempting to produce new low temperature records, Tech's laboratory is principally engaged in work on the physics of the solid state. A solid's structure can be studied more easily if the thermal motion of the molecules is almost stilled. Another important function of the lab is the training of future researchers, for much of the lab's work is carried on by students doing theses. There will also be many practical and useful applications of low temperature physics, such as the elimination of thermal noise in communications equipment, when technical developments allow liquid air or helium to become reasonably cheap. Liquid air is already used in some commercial processes.

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long-range weather forecast

(*Continued from page 26*)

March through most of April . . . the geographical forecast probably will indicate a moderate excess of rainfall for Northern New England in April. Hence everything favors the long-range outlook issued on March 4, of a cool, moderately wet period for the next three or four weeks, probably followed by a warm, dry early summer (May and June)."

The forecast for the period from March 4 until the beginning of April seems to have been quite accurate. By the time this magazine is sold, the correctness of most of the remaining part of the prediction will have been determined. However, whatever this should reveal, it must be agreed that the M. I. T. forecasts have been among the most successful attempts heretofore made in the field.

SPRINGBOARD TO A CAREER IN ENGINEERING

by J. F. ROBERTS
Manager, Hydraulic Department
General Machinery Division
ALLIS-CHALMERS MANUFACTURING COMPANY
(*Graduate Training Course 1919*)

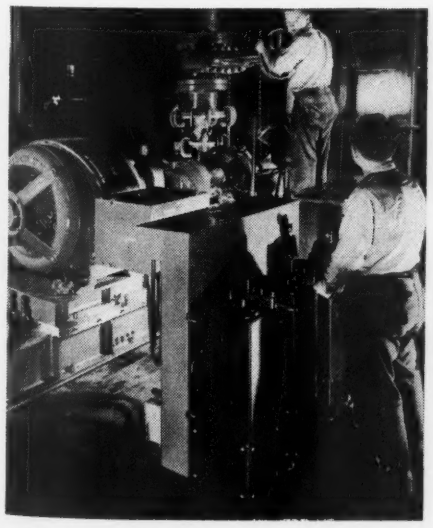
J. F. ROBERTS

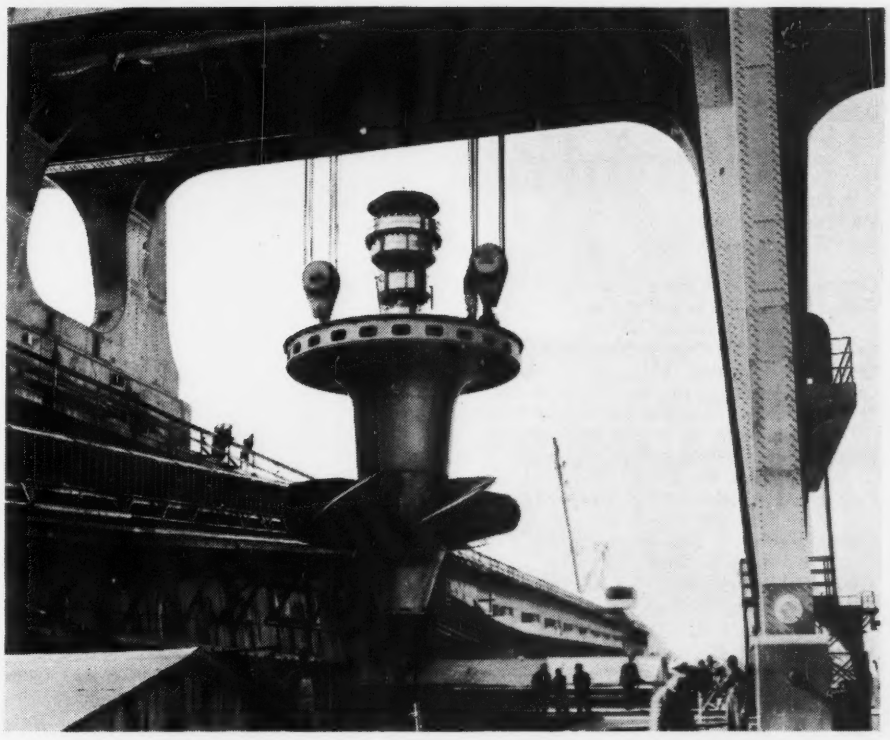
YOU HAVE to start somewhere—and as far as I know, flagpole painting is the only job where you start at the top. Next best thing is to get in where there are many opportunities, and many interesting, worthwhile paths to follow—particularly if you are not entirely sure just what type of work you want to do. You then have a chance to try more than one field, and eventually find the work that will give you the most in satisfaction and success.

Growth of Hydraulics

The field I'm best qualified to discuss is hydraulic engineering. Crude waterwheels were man's first mechanical source of power. Today, in highly perfected modern form, they're still a major source of abundant, low-cost electric power. The field is constantly expanding and holds a world of opportunity. Hydraulic power becomes increasingly important to the nation as the need for low-cost power steadily increases. Moreover, a hydraulic plant once installed produces energy with a minimum of manpower. There's no fuel to mine, prepare, ship, unload and burn—small operating personnel is required.

Right now at Allis-Chalmers we're designing and building turbines for vast new hydro-power projects, not only for the U.S.A. and Canada, but also for Mexico, South America, Norway, New Zealand and the Philippine Islands. We're also restoring many veteran turbines to better-than-original efficiency and capacity after long years of faithful performance.


Graduate students conduct performance tests of centrifugal pump units.


Kentucky Dam TVA Field erection view of 250-ton gantry crane lowering hydraulic turbine assembly. One of five 44,000 hp, 48-ft. head, Kaplan type turbines.

Hydraulics was a field that I hadn't seriously considered as an undergraduate at the University of Wisconsin. I graduated as a Mechanical Engineer in 1918, and entered the Allis-Chalmers Graduate Training Course in January 1919. It was there that I got interested in the big waterwheels.

My first assignment was in steam turbine erection. Then I moved over on the hydraulic turbine test floor. In May 1919 I was sent to North Carolina on the acceptance tests of a big hydro-electric power installation. I continued with hydraulic field work such as tests and trouble shooting until 1925, when I went into the sales end of the work. Two years later I left the manufacturing side and became Hydraulic Engineer for the Power Corporation of Canada, supervising the design and installation of some 15 plants.

In 1936 I became Hydraulic Engineer for the U. S. Government TVA, involving 12 projects and 30 large units. I returned to Allis-Chalmers in 1942 as Manager of the Hydraulic Department—and had the unique experience of building some of the same turbines that I had purchased for TVA.

Vantage Point for All Industries

These personal notes serve to illustrate two interesting facts about the Allis-Chalmers Graduate Training Course. First, it's tailor-made for each student. Since 1904, graduate students here have been helping plan their own courses—making changes as they went along and new interests developed. They've had an opportunity to divide their time between shop and office—follow important projects through from drafting board to installation.

Second, the organization is in close contact with virtually all phases of industry: hydraulic or steam electric power plants and utilities; mining, smelting and rock products; public works; steel and metal working; textiles; food processing; flour milling. Allis-Chalmers builds basic machinery for ALL these industries and many more. Its engineers, executives, salesmen and production experts have a ringside seat for industry in action.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

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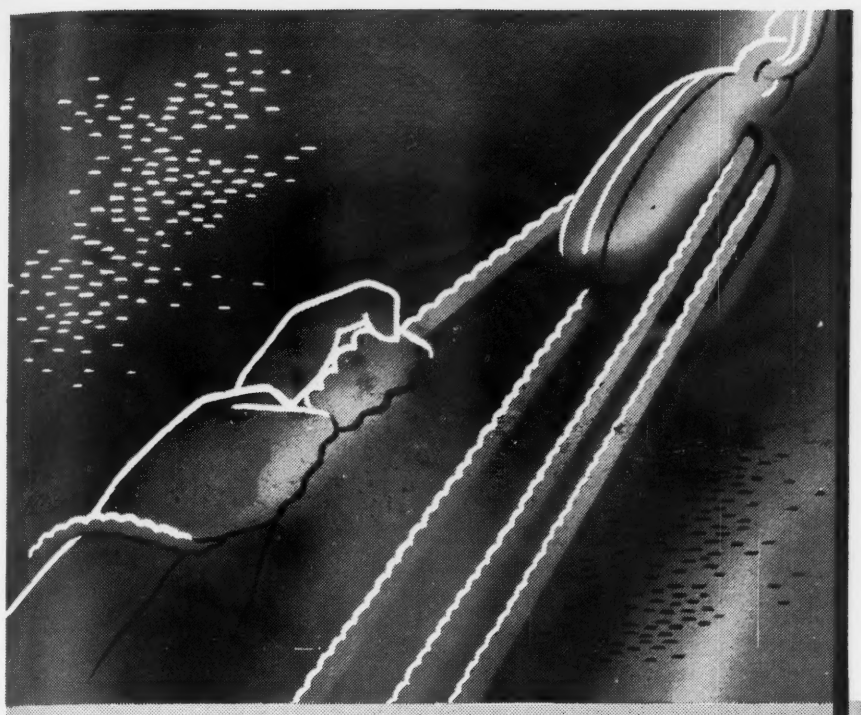

When sail trimming is required

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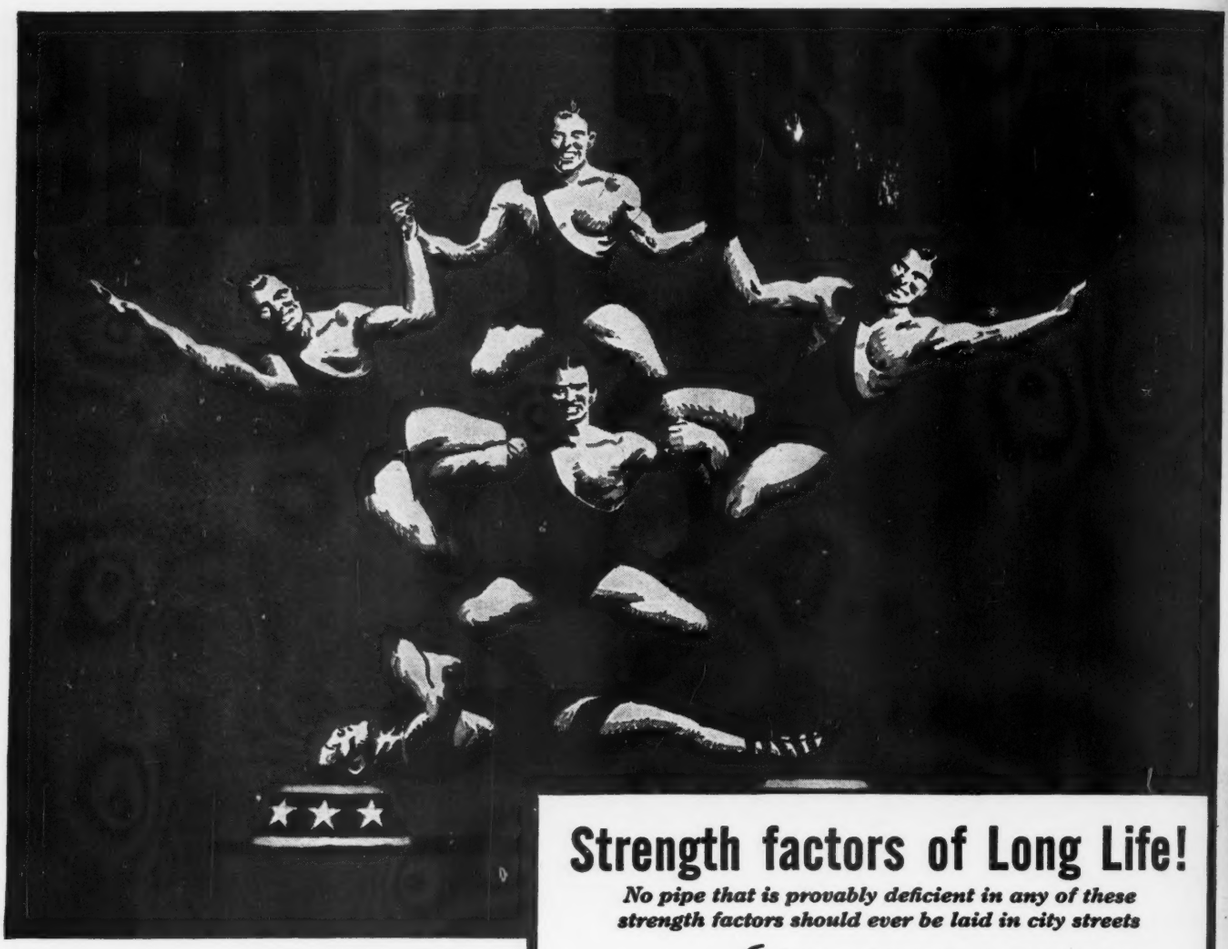


Strength factors of Long Life!

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

BEAM STRENGTH — When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

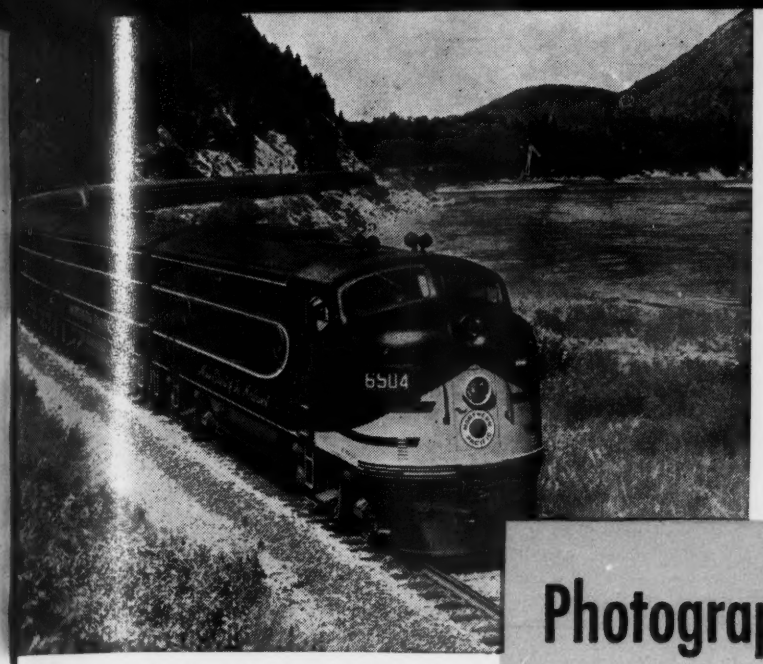
CRUSHING STRENGTH — The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

SHOCK STRENGTH — The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times *on the same spot* from progressively increased heights of 6 inches.

BURSTING STRENGTH — In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

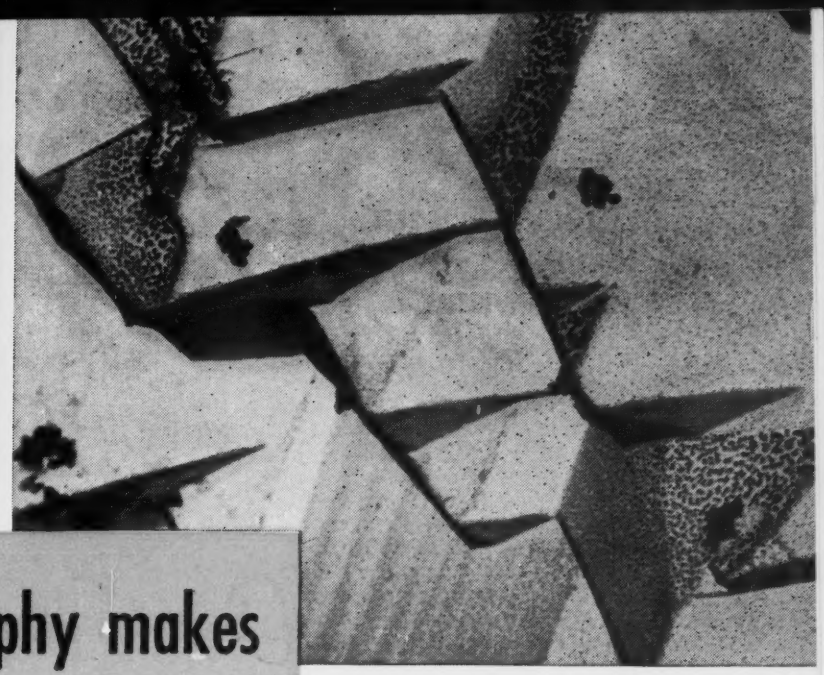
Without beam strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today. But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada. Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety. No pipe that is provably deficient in any of these strength factors should ever be laid in city streets. Cast Iron Pipe Research Association, Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

CAST IRON PIPE SERVES FOR CENTURIES

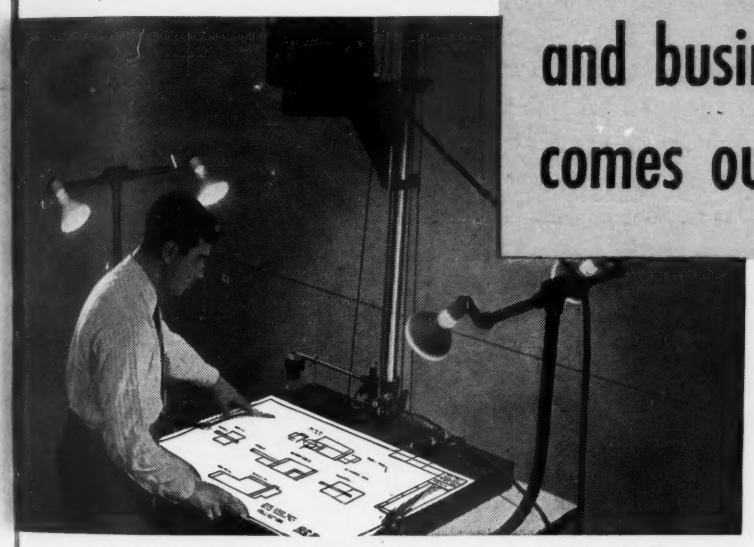


DISPLAYS MASSIVE PRODUCTS—A Diesel locomotive can roar across the Rockies—all on a movie screen in a prospect's office. All because photography can take huge things or small, and make them of a size for a salesman, teacher, or demonstrator to show.

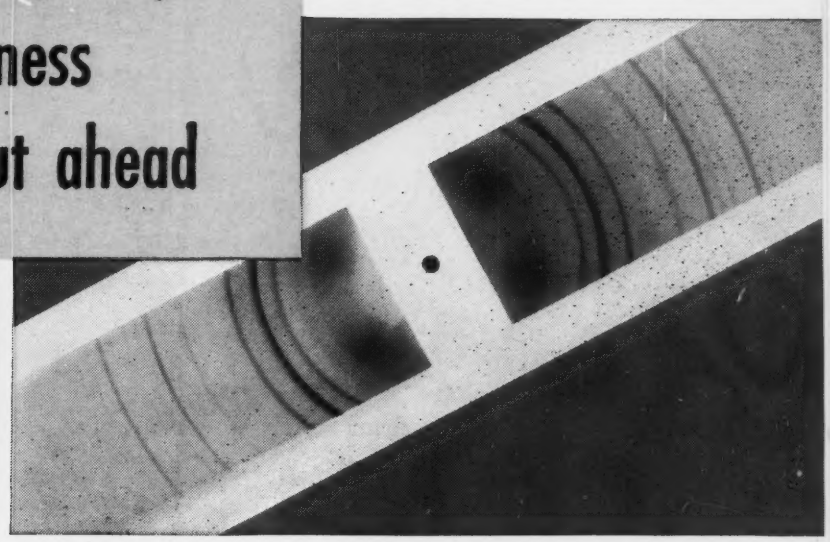
Photography makes big things small—small things big—and business comes out ahead



MAKES MICROSCOPIC DETAILS CLEAR—Photography takes great magnifications produced by the electron microscope (20,000X) on fine-grain Kodak plates, enlarges and records them up to 100,000X on Kodak projection papers. Previously undetectable details and new facts are revealed.



REDUCES FILING SPACE BY 98%—With microfilming, bulky records can be reduced and stored on a few rolls of film. 675 drawings, 24" x 36", can be recorded on a 100' roll of 35mm. Recordak or Kodagraph Micro-File Film. And everything is quickly ready for reference in the Recordak or Kodagraph Film Reader.



REVEALS STRUCTURE AND CONDITION OF METALS—X-ray diffraction patterns on Kodak films or plates provide important information concerning the crystal structure of metals. These patterns help show how alloys can be improved or new alloys made—give data on the effect of machining, drilling, and punching upon the structure of the material.

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...given the facts
NOTHING IS WISER

On Bigness

We are today a much larger country than we were short years ago. Comparing 1930 with 1948, Federal government expenditures have grown from $3.6 billion to $40 billion. National income has grown from $75 billion to $226 billion.

* * *

Is small business holding its own with big business in this growth? Or being driven from the American scene, concentrating business into a few hands?

* * *

In 1900, there were 15 firms for each 1000 people. Today there are 18. (Apparently small business is not losing ground.) The average firm has the same number of employees as at the beginning of the century.

* * *

According to a survey by the Federal Reserve Board covering approximately 2,000 concerns, during the war, the small and medium-sized firms in total increased their profits, assets and net worth faster than did large concerns. In 1948, there were in operation one-third more business units than in 1944.

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Can new businesses crowd in and climb to the top? In 1935, to take the electrical business as an example, only 153 companies did over $500,000 business. By 1947, there were over 342 companies with sales in that higher bracket.

* * *

General Electric, in spite of its growth during the past 20 years, has only been able to keep pace with the growth of industry and of the country. We estimate that our percentage of production in the electrical industry was about 23% in 1930, 25% in 1940, and is today approximately 24%.

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It is the job of all business and all industry to supply the ever-expanding needs of people. Big jobs require big tools. No company and no industry in the American economy is yet big enough to bring enough goods to enough people.

You can put your confidence in—

GENERAL ELECTRIC